

Proceedings of the SLTw Webinar 2020 on Applied Research for Sustainable Development

Editors

Prof. Chia-Lin Chang

Prof. Namal Priyantha

Prof. Hsiharng Yang

**New Southbound Scheme for Expansion in Sri Lanka Project
funded by Taiwan Ministry of Education**



**National Chung Hsing University, Taiwan
University of Peradeniya, Sri Lanka**

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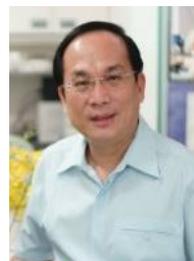
National Chung Hsing University, Taiwan
University of Peradeniya, Sri Lanka

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Message of the Vice-President

Welcome to join this conference! Particularly, several scholars in Sri Lanka will make presentations through online meeting due to COVID-19 issue. Otherwise, we wish to meet each other face to face with good friendship. Our good friend, Prof. Namal, and other professors from several universities in Sri Lanka and our professors working on similar research fields are appreciated. It is our great pleasure to invite you to join SLTw Webinar Series 2020 (STWS 2020) on Applied Research for Sustainable Development. Since 2017, we keep the idea "Beyond Islands: Academic Networking between Taiwan and Sri Lanka" to enhance NCHU and Sri Lankan Universities' cooperation.



This event will provide a unique opportunity to have fruitful discussions about some topics related to but are not limited to clean energy, environmental issues, and nanotechnology. STWS 2020 is organized by the Office of International Affairs, NCHU, under the project "New Southbound Scheme for Expansion in Sri Lanka" supported by the Taiwan Ministry of Education. The concept of the STWS 2020 is to bring together bright minds who dedicate their research work and efforts to some of the most important topics nowadays. Besides, your contributions to this webinar will help you meet both Taiwan and Sri Lankan experts work in your specialization area and open doors to build up and expand the academic collaborations between Taiwan and Sri Lankan Universities.

Currently, NCHU has about 800 international students from overseas. These students are around 5% of the total students. Our target will reach 10%, in terms of 800 students more from overseas will be recruited in the future. NCHU will continue to raise more scholarship to encourage qualified students from overseas. Students from Sri Lanka are essential to this program. OIA proposes a Pre-Approval strategy. Excellent students recommended from his/her

professors and proved from NCHU professors with admission will be granted a scholarship before their arrivals. NCHU is located in Taichung, Taiwan. It's a mid-size city with an affordable living cost. NCHU has many research projects supporting students engaged in many advanced research directions if they join NCHU. Also, we look forward to seeing both countries inspired more academic interactions in the future. Thank you for your attention.

Prof. Chang-Hsien Yang

Vice-President, National Chung Hsing University, Taiwan

Message of the Vice-President for International Affairs

As the Vice-President for International Affairs, National Chung Hsing University (NCHU), it is a great pleasure and honour to welcome all the participants for the SLTw Webinar Series 2020 on Applied Research for Sustainable Development.



I am honoured to welcome Distinguished Professor Yang, Chang-Hsien, Vice-President of NCHU, all the eminent speakers from Sri Lanka, representing five leading universities, from Taiwan, and all members of the National University System of Taiwan (NUST), distinguished guests, and participants who are here to share their knowledge and vast experience.

SLTw Webinar 2020 is organized by the Office of International Affairs, NCHU, under the project “New Southbound Scheme for Expansion in Sri Lanka”, supported by the Taiwan Ministry of Education. This event will provide a unique opportunity to have fruitful discussions about some topics related to, but not limited to, clean energy, environmental issues, and nanotechnology.

In recent years NCHU has organized several international conferences and workshops, and have invited Sri Lankan scholars to visit Taiwan to participate and contribute their knowledge and experience. However, because of the COVID-19 pandemic, it is not possible for the event at this difficult time. Therefore, we plan to have a webinar of 4-hour duration and invite speakers from the leading Sri Lankan state universities to contribute and participate.

The concept of the webinar is to bring together bright and sharp minds who have dedicated their research work and effort to tackle some of the most important and challenging topics now facing the international community. Your contributions to the webinar will help you to meet both Taiwan and Sri Lankan experts who work in your specialized areas, and open doors to create and

expand exciting academic collaboration between leading Taiwan and Sri Lankan universities for the future.

I am most pleased to acknowledge all the delegates and support teams who have contributed their significant time and effort over an extended period to establish an international webinar series of which we are sure to be immensely proud. I wish everyone a successful, safe, and fruitful webinar.

Prof. Chia-Lin Chang

Vice President for International Affairs, National Chung Hsing University,
Taiwan

Message of the Deputy Vice-President for International Affairs

It's a great pleasure to hold this wonderful online event today. I am Professor Hsiharng Yang in charge of the project "New Southbound Scheme for Expansion in Sri Lanka" supported by the Taiwan Ministry of Education. It's been for a few years of academic interaction between NCHU and Sri Lankan universities. Our mission is to recruit more excellent students from Sri Lanka to join NCHU. Based on this mission, the Ministry of Education in Taiwan strongly encourages NCHU to explore all opportunities for recruiting international students to Taiwan.



This expansion project covers some works including the website maintaining, scholar visiting invitation, outbound visiting, hosting for the international conference, etc. Due to COVID-19 pandemic issue, such visits are impossible for both sides. The online meetings were carried out for both organizers and contributed to this webinar. It's much appreciated for co-workers from both sides.

NCHU is comprehensive research-led university including various subjects to attract young people to study. There are several hundred research projects carried out at NCHU every year. These projects also foster young people engaged in both academic and industrial research. It's a good chance for the youth to spend their time to prepare their careers at NCHU. The webinar is based on the idea to invite some scholars and introduce related research themes. Currently, energy, environment, material chemistry and biotechnology are included. We look forward to introducing more themes in the future.

Prof. Hsiharng Yang

Deputy Vice President for International Affairs, National Chung Hsing University, Taiwan

Message from the Sri Lankan Co-PI and Coordinator

I am pleased to provide this message for the Proceedings of the Webinar conducted on “Beyond Islands: Academic Networking between Taiwan and Sri Lanka” under the SLTw Webinar Series 2020, organized by the Office of International Affairs of National Chung Hsing University (NCHU). Academic collaborations between NCHU and



Sri Lankan universities date back to 2016 when the first joint workshop on Entomology was held at the Postgraduate Institute of Science, University of Peradeniya, Sri Lanka. Since then, many joint symposia and academic collaborations were held on various timely and relevant themes.

The main theme of this Webinar, held on 29th of October 2020, was Applied Research for Sustainable Development, which was arranged under two main categories: Chemistry and Nanomaterials; and Environment and Energy. Sixteen resource persons representing both Taiwan and Sri Lankan universities disseminated their findings in this webinar, followed by fruitful discussion sessions. The Proceedings of the Webinar includes 13 extended abstracts compiled based on the presentations delivered at the Webinar. I have no doubt that the Proceedings will take the message of the Webinar presentations further to the international level.

I am thankful to the presenters who contributed to the Proceedings by providing extended abstracts, and further, I deeply appreciate the efforts of the Organizing Committee headed by Prof. Chia-Lin Chang and Prof. Hsiharng Yang to make the Proceedings a success.

Prof. H. M. D. N. Priyantha

Sri Lankan Co-PI and Coordinator, University of Peradeniya, Sri Lanka

SESSION: CHEMISTRY AND NANO-MATERIALS

Session I

Session Chair:

Prof. Tung-Wen Sun

Vice President, International & Cross-Strait Affairs,

National Chi Nan University, Taiwan

Session II

Session Chair:

Prof. Chen-Hao Wang

Vice Dean, Research and Development,

National Taiwan University of Science and Technology, Taiwan

Fibrous Keratin Protein Bio-microstructure for Efficient Removal of Hazardous Dye Waste from Water: Surface Charge Mediated Interfaces for Multiple Adsorption-Desorption Cycles

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Abstract

Merino wool yarn based keratin protein fibers were surface hydrolyzed by treating wool yarn in 0.5 M NaOH solution. During the hydrolysis, wool yarn was provided with comparatively higher degree of free amine and other surface functional groups. Wool yarn treated with 0.5 M NaOH (0.5 M wool) showed exceptional absorption of rhodamine dye from an aqueous solution compared to a control wool yarn in the presence of acetic acid. Scatchard analysis of the isotherms of 0.5 M wool confirmed the existence of multiple binding sites present in the material. The main absorption was due to the free amine and carboxylic groups on the 0.5 M wool sample. It was also observed to have charge induced absorption due to the protonation of amine groups on the surface hydrolyzed keratin protein fibers in acetic acid medium. In the presence of 3.5% acetic acid in the aqueous dye medium, 0.5 M wool showed 95% absorption at 298 K. The dye removal efficiency of the 0.5 M wool sample remains at 95% even after four adsorption-desorption cycles. Combining the high absorption capacity and recyclability, surface hydrolyzed wool (0.5 M wool) can be a promising bio-material to remove carcinogenetic Rhodamine B (C.I 4570) dye from aqueous medium modulated by acetic acid.

Introduction

Contamination of water with dye waste has become a major issue globally. Over 10,000 varieties of dye types are used by many industries for coloration purposes. In the textile industry, approximately 12% of dye is lost during the manufacturing and dyeing processes. From these, 20% of the lost dyes enter into water streams as industrial waste water, damaging the aquatic ecosystem and human health [1-3]. Thus, many technologies were developed for removal of dye waste from contaminated water. Among these, chemical precipitation, ion exchange, membrane filtration, physical adsorption, chemical oxidation/reduction and bio-removal are the most commonly practiced methodologies for the removal of dyes and other hazardous materials from waste water [4-6]. IN the recent past, bio-based adsorption methods or filtration membranes have

gained interest due to their attributes as efficient, cheap and ecofriendly methodologies [7].

Wool keratins consist of highly conserved 19 amino acid sequence, rich with carbon, hydrogen, nitrogen and sulfur, linked together by peptide bonds [8,9]. Therefore, wool is abundant in amine and amide functional groups. Quaternary ammonium based material adopting a positive charge on its surface in acid and alkaline medium has made them a feasible candidate for complicated effluent treatment [10]. This research study has focused on modification of the wool material using alkaline hydrolysis. The study has found that alkaline hydrolyzed wool improved the dye absorption by 25 times compared to the non-hydrolyzed wool material. During the hydrolysis process, it is hypothesized that the surface of the wool is modified favoring the adsorption of dye molecules in the dye bath. To identify possible mechanism for strong dye absorption, dye-fiber interaction behavior was studied using different methods. In this study, a novel bio-coagulant derived from wool yarn for efficient removal of dyes from an acid dye bath is reported.

Materials and Methods

Merino wool fibers (average diameter: 15 μm), glacial acetic acid (99% purity) and sodium hydroxide (99.8% purity) were obtained from Sigma-Aldrich. Rhodamine B (C.I 4570) dye was a kind gift from Stretchline Pvt. Ltd. (Sri Lanka). Deionized water was used in all experiments.

Merino wool fibers were first washed using distilled water to remove any dust particles or impurities. Wool fibers (0.125 g) were hydrolyzed in 40 mL of 0.1 M, 0.3 M, 0.5 M, 0.8 M and 1.0 M NaOH solutions separately for 10 min at room temperature. The resulting dispersions were centrifuged at 9000 rpm, and the supernatant was discarded. The precipitate was washed with distilled water using centrifugation for multiple times until the pH of the wool dispersion became neutral. Washed wool samples were dried at 60 $^{\circ}\text{C}$ to remove excess water. Hydrolyzed, washed and dried wool samples were labelled as 0.1 M wool, 0.3 M wool, 0.5 M wool, 0.8 M wool and 1.0 M wool according to the molarity of the alkaline medium used for hydrolysis.

percentage of dye reduction =

$$\frac{(\text{peak area of the dye solution without wool} - \text{peak area of the dye solution with wool}) \times 100}{\text{Peak area of the dye solution without wool}}$$

UV-Vis spectrophotometer (Shimadzu UV-Vis 3600) was used for the dye adsorption studies. UV-Vis spectra of the dye samples were obtained using the transmittance mode of the spectrophotometer in the wavelength range of 400 – 800 nm. The peak area of the spectrum at 533 nm was obtained. Percentage of color reduction of each dye solution was calculated using the equation given below. Comparison of the dye reduction using different wool yarn samples (hydrolyzed and non-hydrolyzed) was given in Figure 1.

Results and Discussion

Efficiency of the hydrolyzed wool fibers for the removal of rhodamine B from aqueous solutions was studied. According to Figure 1, hydrolyzed wool fibers have very high dye removal capability which is 74% compared to 4% shown by pristine wool fibers. Further, 0.5 M wool fibers showed ~96 % dye removal from a 100 mL of 100 ppm dye solution (in 3% acetic acid medium) within 40 min time period. Therefore, among different alkaline hydrolyzed wool fibers and pristine wool fibers, 0.5 M wool sample showed the highest adsorption for rhodamine dye and hence it was selected for further adsorption studies.

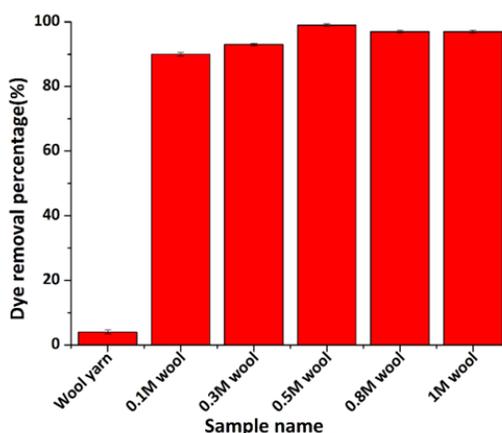


Figure 1: Dye removal percentage of wool and hydrolysed wool samples

The fibrous nature of the 0.5 M wool sample with a fiber diameter of ~30 μm and length > 2 mm allows the material to be separated from aqueous medium and easily regenerated. The reusability of the adsorbent was assessed by performing multiple adsorption-desorption cycles. Adsorption of Rhodamine B dye was carried out for 100 mL of 80 ppm dye at fixed 0.8 g L⁻¹ loading of 0.5 M wool for a predetermined equilibrium time (30 min) period. For the adsorption cycle, the dye solution is charged with 3.5% acetic acid at pH 2. The desorption of the dye molecules from 0.5 M wool was achieved in 100 mL aqueous solution with 0.5% NaOH at pH 10 for 30 min time period. The adsorption and desorption percentages of the dye to and from the 0.5 M wool sample for three adsorption-desorption cycles are given in Figure 2. The corresponding photographs of the dye solution in each adsorption-desorption cycle are given in Figure 2. During the first three cycles, the dye removal percentage was at 95%, while it slightly reduced to 94% after the fourth cycle. During desorption, 97% (78 ppm) of the dye was eluted to the aqueous solution. The desorption of Rhodamine dye from 0.5 M wool can be due to the deprotonating of cation and amine groups present in the sample under alkaline condition. During the desorption, negative charge of the surface of the sample

would increase, thereby repelling dye molecules to the aqueous medium, allowing the functional groups to be vacant for the next adsorption cycle. The results show that the dye adsorption ability of 0.5 M wool sample remains effective after multiple number of use, thus it can be reused.

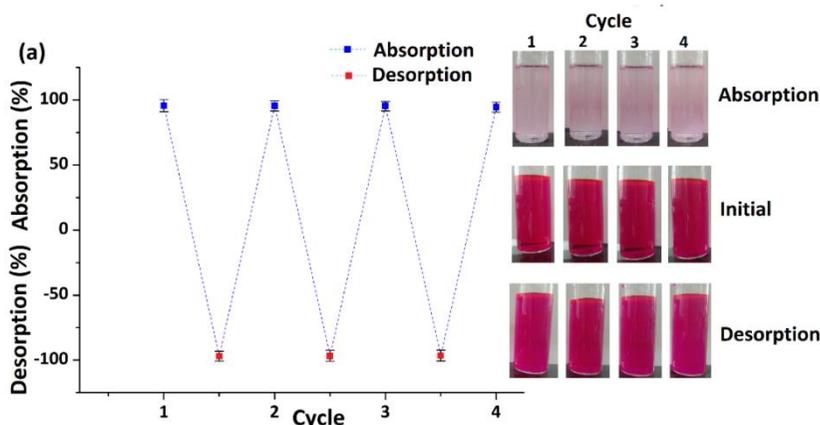


Figure 2: Adsorption and desorption behaviour of 0.5 M wool sample under acidic and alkaline conditions.

Conclusion

A keratin protein based bio-adsorbent was prepared via controlled alkaline hydrolysis of wool fibers. Fiber treatment has allowed removing the outer surface of the wool fiber which allows more dye adsorption compared to the unmodified wool fiber. It can be observed that surface hydrolysed wool material had ~90 times higher Rhodamine dye adsorption compared to an unmodified wool fibers. The alkaline hydrolysis also has introduced chemical functional groups on the fibers surface which was found to be contributing towards the high adsorption. Another interesting property of the prepared keratin protein based wool material is that the same system can be regenerated in alkaline medium and used in several dye adsorption cycles with adsorption efficiencies close to 95%. In view of the simple preparation method of the adsorbent, its reusability, high adsorption capacity and decomposability, it is expected that surface hydrolysed wool material can be applied for dye wastewater remediation through different techniques.

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Biography:



Prof. Rohini M. de Silva is a Professor in Chemistry at the University of Colombo, Sri Lanka. She obtained her B.Sc. (Chemistry, First Class) from the University of Colombo, Sri Lanka and Ph.D. from the University of Cambridge, UK. She gained postdoctoral experience in Nanotechnology at the Center for Advanced Microstructures and Devices (CAMD), Louisiana State University, USA. Her main research focus areas are water purification, textiles and apparel, natural resources and nano-biotechnology. Presently, she is also serving as the President (E2 Section, Chemical Sciences) of Sri Lanka Association for the Advancement of Science (SLAAS).

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Oxide-metal Nanocomposites and Their Optical Properties

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Abstract

Without using templates, seeds and surfactants, we successfully prepared multi-oxide-layer coated Ag nanowires that enable tunable surface plasmon resonance without size or shape changes. A spontaneously grown ultra-thin titania layer onto the Ag nanowire surface causes a shift in surface plasmon resonance toward low energy (high wavelength) and also acts as a preferential site for the subsequent deposition of various oxides, *e.g.* TiO₂ and CeO₂. The difference in refractive indices results in further plasmonic resonance shift. This verifies that the surface plasma resonance wavelength of one-dimensional nanostructures can be adjusted using refractive indices and shell oxide thickness design.

Introduction

Metal-oxide core-shell nanowires have emerged to improve the functionality and applicability of metal nanowires. For instance, Ag@TiO₂ nanowires show many advantages when used as the photoelectrodes for dye-sensitized solar cells [1], *e.g.* the prevention of electron-hole recombination and anti-corrosion from electrolytes. Moreover, the surface plasmon resonance of core-shell nanostructures encourages the enhanced localized electromagnetic field, which provides light absorption improvement by dye molecules and thus a better harvesting efficiency than traditional TiO₂ electrodes.

With respect to synthetic one-dimensional metal-oxide core-shell nanostructure production methods, Dong *et al.* [2] used hydrolysis with post-annealing to obtain anatase TiO₂ shell onto Ag nanowires. However, the Ag core might be damaged or even disrupted. Eom *et al.* proposed a sophisticated and complicated process [3], including the application of nanoimprint and evaporation techniques to fabricate Ag nanowires onto polymer templates. This was followed by TiO₂ electrodeposition onto the Ag nanowire surface. Most metal/CeO₂ core-shell structures are successfully synthesized in the form of nanoparticles, but only a few researchers have developed core-shell nanowires.

Core-shell nanowires with a metal core and dual-oxide shells comprising native oxides are the only ones that have been successfully synthesized, *e.g.* Cu/Cu₂O/CuO or Cu/Cu₂O/ZnO [4,5]. Our group successfully synthesized template-free and surfactant-free Ag nanowires with a uniform spontaneous ultra-thin titania shell (~0.5 nm) on TiO₂ coated Si substrate [6]. The titania was denoted as TiO_{2-x} due to a deficiency of oxygen. Using these ultra-thin TiO_{2-x} coated Ag wires as the template, this study proposes a facile method to prepare metal-cored nanowires with multi-oxide shells. EELS and UV-visible spectroscopy were conducted to explore the influence of oxide shell variation on the Ag nanowire plasmon resonance properties.

Materials and Methods

Figure 1 illustrates the workflows used to synthesize Ag-cored nanowires with multi-oxide shells. TiO₂ thin films were prepared via the sol gel method by dipping Si wafers into the gels and then they were spun at 1000 rpm for 30 s. The TiO₂ solutions consisted of isopropylalcohol (IPA)/titanium isopropoxide (TTIP)/hydrogen chloride (HCl) with a volume ratio of 170:12:0.4, which were aged at room temperature (20 °C) for 2 days before dipping. The coated samples were annealed at 500 °C in an oxygen atmosphere for 8 h to achieve better crystallinity.

Fifteen µl of 0.05 M silver nitrate (I) (AgNO₃) solution was dropped onto the TiO₂ substrate, and then subjected to proper UV exposure (Step 1 and 2 in Figure 1). Heat treatment was conducted at 300 °C for 3 h, followed by furnace-cooling (Step 3). The parameters of the heat treatment for nanowire synthesis were determined based on our previous investigations [7]. The TEM image and selected area diffraction pattern given in Figure verify that the obtained Ag nanowires were single crystalline growing towards [220]. The average wire diameter ranged from 100~150 nm, and the average length was 8.3 µm. In step 4, the synthesized Ag@TiO_{2-x} nanowires served as templates and were dipped into 0.05 M titanium tetrachloride (TiCl₄) or ammonium ceric nitrate [Ce(NO₃)₃·6H₂O] aqueous solutions. Reactions were held at 200 °C for 4 h.

Results and Discussion

Figure 2 shows the XRD diffraction pattern of Ag nanowires (Ag/TiO_{2-x}) and those coated with TiO₂ and CeO₂ (Ag/TiO_{2-x}/TiO₂ and Ag/TiO_{2-x}/CeO₂). For Ag/TiO_{2-x} samples, only diffraction peaks of Ag were detected. In addition to the Ag diffraction peaks, Ag/TiO_{2-x}/TiO₂ nanowire samples also reveal anatase-TiO₂ signals, while Ag/TiO_{2-x}/CeO₂ nanowires show both the Ag and CeO₂ diffraction peaks.

For Ag/TiO_{2-x}/CeO₂ nanowires, STEM-HAADF images and corresponding EELS elemental mapping are respectively shown in Figure 3(a) and 3(b). They clearly show the dual shell feature of Ag/TiO_{2-x}/CeO₂ nanowires, *i.e.* Ti-rich inner shell and Ce-rich outer shell. The thicknesses of inner and outer shells

were about 1 nm and 4~6 nm, respectively. The lattice spacing, 0.31 nm shown in Figure 3(c), is consistent with that of CeO₂ (111) planes. Diffraction patterns of a selected area shown in Figure 3(d) reveal spots from crystalline Ag nanowire and rings from CeO₂ nanocrystals. TiO_{2-x} between the Ag wire and CeO₂ was too thin to be observed in Figure 3(d).

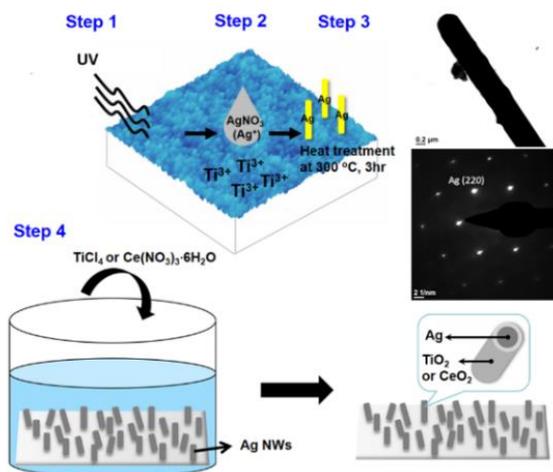


Figure 1: Synthesis process schematic illustration the steps for obtaining Ag nanowires with multi-oxide-shells - Step 1: UV irradiation on TiO₂ substrate; Step 2: Dropping AgNO₃ solution on TiO₂ substrate; Step 3: Heat treatment for forming Ag nanowires; Step 4: Coating of outer oxide shells, as well as the TEM analytical results of the synthesized Ag nanowires (TEM image and selected-area diffraction pattern).

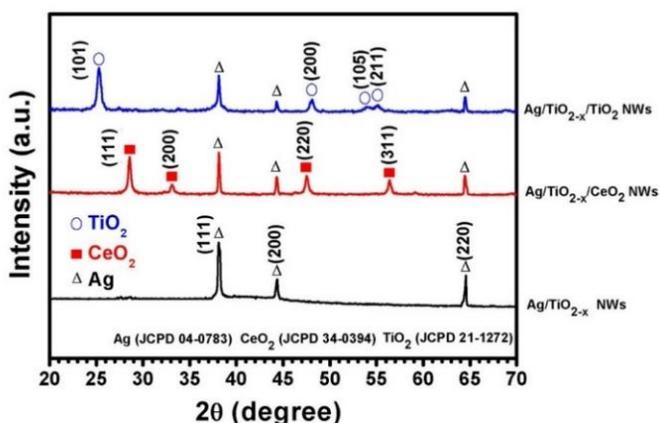


Figure 2: GIXRD patterns of the Ag/TiO_{2-x}, Ag/TiO_{2-x}/TiO₂ and Ag/TiO_{2-x}/CeO₂ NWs (The shell thicknesses were 1 nm for TiO_{2-x}, 5~7 nm for TiO₂ and 4~6 nm for CeO₂).

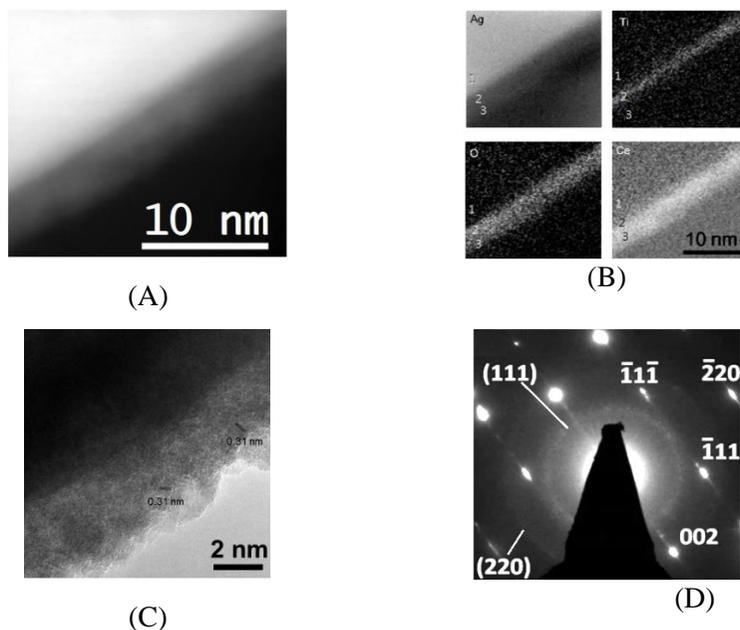


Figure 3: Ag/TiO_{2-x}/CeO₂ nanowire oxide shell microstructure analytical results: (A) HAADF image, (B) EELS elemental mapping taken from the marked region in (A) (point 1, point 2 and point 3 indicate Ag wire, TiO_{2-x} and CeO₂ respectively), (C) HRTEM images and (D) selected area diffraction patterns.

Figure 4(a) illustrates the UV-Vis spectra of Ag@TiO_{2-x} nanowires and those with TiO₂ or CeO₂ outer oxide shells. Ag@TiO_{2-x} shows an absorption peak at 408 nm. It is worth noting that further coating with a second oxide shell, TiO₂ or CeO₂, gave rise to a red shift in the absorption peaks to 426 nm (Ag/TiO_{2-x}/TiO₂) and 420 nm (Ag/TiO_{2-x}/CeO₂). The low-loss EELS region (Figure 4(b)) indicates Ag nanowires without any oxide shell and surfactants exhibited a localized surface plasmon resonance (LSPR) at 3.40 eV (364 nm). SPR can be red-shifted due to spontaneously-grown ultra-thin oxide shell (inner shell) as well as an additional oxide layer (outer shell). As illustrated, LSPR appeared at 3.25 eV (382 nm) for Ag/TiO_{2-x} nanowires. A thicker extra oxide layer resulted in a greater shift, *i.e.* 3.16 eV (392 nm) for Ag/TiO_{2-x}/CeO₂ nanowires and 3.08 eV (403 nm) for Ag/TiO_{2-x}/TiO₂. The above results imply that the LSPR location can be tuned by the number of layers and oxide shell material selection, as well as the thickness control.

The peak shift can be related to the oxide layer refractive indices. With respect to the oxide shells in our cases, the TiO₂ refractive index is 2.54 [8], while that of CeO₂ is 2.2 [8]. The fact that TiO₂ has a higher refractive index than CeO₂ explains the greater red shift in TiO₂-covered nanowires compared to Ag/TiO_{2-x}/CeO₂ nanowires.

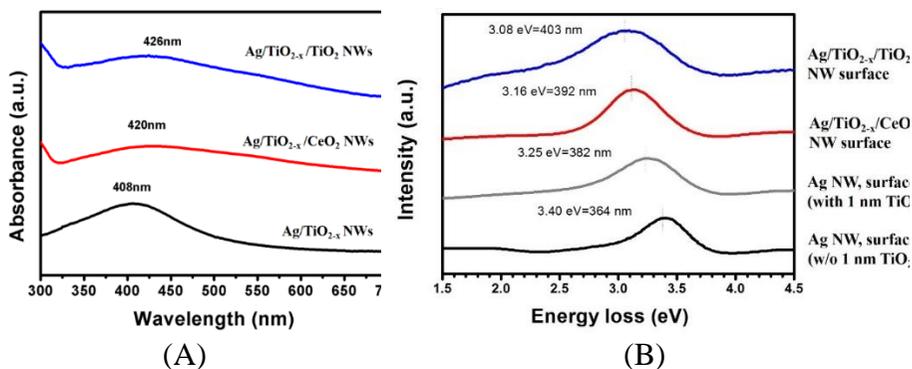


Figure 4: Nanowire optical properties: (A) UV-visible absorption spectra, and (B) low loss region of EELS.

Conclusions

A simultaneously-grown ultra-thin oxide on the Ag nanowire surface leverages the buffering characteristics for developing multi-oxide shell metal-cored nanowires. The EELS mapping demonstrates that an ultra-thin TiO_{2-x} layer with a thickness of about 1 nm fully covers Ag nanowires. Further deposition of similar or dissimilar oxides can proceed readily. The spectra result at the low-loss peak region verify surface plasmon peak resonance variation. The covering of one spontaneous TiO_{2-x} layer at approximately 1 nm on the Ag nanowire surface causes the shift in surface plasmon resonance toward low energy (high wavelength). Additional outer oxide shells magnify the shift. The LSPR shift can be controlled through the oxide refractive-index selection. This study sheds light on the possibility of one-dimensional nanostructure preparations that enable tunable surface plasmon resonance without shape changes.

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Biography:



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High Performance of Metal Oxide Catalyst for Vanadium Redox Flow Battery

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Introduction

With the utilization and development of new energy technology, people's demand for a large-scale energy storage system (ESS) has become increasingly urgent. Among the ESS, vanadium redox flow battery (VRFB) is one of the most promising technologies, especially for large-scale production, due to its unique features, such as high safety, long cycle life, and flexible design [1]. However, it has been limited for real applications because of its high production cost and low energy efficiency. Figure 1 illustrates the operating principle and the fundamental structure of a VRFB. The battery consists of two electrolyte reservoirs and the cell stack, in which an ion-exchange membrane is used to separate the two half-cells. The two reservoirs have contained V^{2+}/V^{3+} and VO^{2+}/VO_2^+ sulfate electrolytes on the negative and positive sides, respectively. Electrochemical activity of the electrode material remarkably influences the energy efficiency and the final cost of VRFB due to the redox reactions of vanadium ion taking place at the electrode surface [2].

Graphite felt (GF) is most commonly used as the electrode for VRFB due to its high chemical stability and low-cost. However, pristine GF exhibits insufficient electrochemical activity and wettability, resulting in the low energy efficiency of the VRFB [3]. Therefore, investigation has been attempted to modify GF to improve its electrochemical performance towards VRFB. GF can be decorated with some less expensive metal oxides, such as WO_3 , ZrO_2 , CeO_2 and so on, which can improve the energy efficiencies of VRFB [2,4,5]. Despite the introduction of metal oxides improve the electrochemical activity of GFs, their low conductivity limit their performance. Therefore, designing novel fabrication techniques to obtain high-performance metal oxide composite electrode materials is crucial. One way to solve the problem above is by incorporating transition metal oxide with reduced graphene oxide (rGO).

Results and Discussion

This work is mainly focused on the modification of GF electrodes using MoO_2 -rGO composite as an electrocatalyst to achieve high energy efficiency of VRFB. In this study, a facile hydrothermal method followed by thermal treatment/annealing was used to synthesize low-cost and high catalytic activity MoO_2 -rGO nanocomposite to improve the electrocatalytic activity of GF

electrodes toward VRFB. Both the XRD and XPS results confirmed that MoO₂-rGO nanocomposite was successfully fabricated. The CV and EIS results showed that the as-prepared MoO₂-rGO nanocomposite-modified GF exhibited outstanding electrocatalytic activities for both V²⁺/V³⁺ and VO²⁺/VO₂⁺ couples among the tested electrodes (MoO₂ and rGO samples). Furthermore, the MoO₂-rGO nanocomposite-modified GF electrode substantially improved the energy efficiency of the VRFB. For example, the energy efficiency of the VRFB using MoO₂-rGO nanocomposite at 80 mA cm⁻² is 78.05%, which is 3.80% and 11.45% higher than the VRFB cell assembled with the rGO-coated GF and pristine GF electrode, respectively (Figure 2).

Conclusion

This improvement can be ascribed to the uniform distribution of MoO₂ nanoparticles on the surface, which might increase the effective surface area and enhance the mass transport at the electrode-electrolyte interface. Furthermore, the high electrical conductivity of rGO, oxygen vacancies on MoO₂, and numerous oxygen-containing functional groups can improve wettability, enhancing the number of active sites for vanadium ion absorption. In summary, MoO₂-rGO nanocomposite is a promising electrocatalyst material to improve the energy efficiency of VRFB, which is suitable for practical applications.

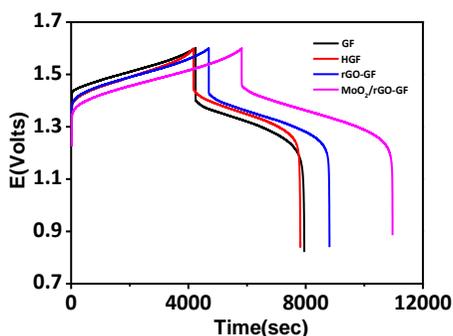
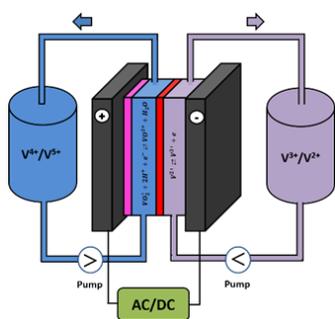


Figure 1. Diagram of the VRFB Figure 2. Charge-discharge test at 80 mAcm⁻²

Keywords: Electrocatalytic activity; Energy storage system; Graphite felt electrode; MoO₂-rGO nanocomposite; Vanadium redox flow battery.

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Recent Publications

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Low-cost Electrodeposited Cuprous Oxide Homojunction Solar Cell

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Abstract

Cuprous oxide (Cu_2O) is a well-known, abundant, low-cost, nontoxic, direct band gap solar energy material. Additionally, electrodeposition is a low-cost, simple, eco-friendly technique that can be used to grow Cu_2O thin films in its both conductivity types. Indeed, interfacial mismatching at the p-n junction and contact resistances are responsible for the reported poor efficiencies of Cu_2O homojunction solar cells. It is evident that, by altering pH value of Cu_2O film deposition bath, the relative band edge positions of Cu_2O can be shifted to minimize the interfacial discontinuities at the p-n junction. Further, sulphidation of the p- Cu_2O thin film surfaces will also reduce the p- $\text{Cu}_2\text{O}/\text{Au}$ contact resistance. In this study, the possibility of improving the efficiency of Cu_2O homojunction solar cell was investigated with a proper choice of bath pH values for n- and p- Cu_2O thin film deposition, and application of surface treatments. Here, n- Cu_2O thin films were electrodeposited on titanium substrates in an aqueous acetate bath. Subsequently, p- Cu_2O thin films were electrodeposited on the Ti/n- Cu_2O electrode in a lactate bath. Then, this bi-layer was annealed at 175 °C for 30 minutes and it is exposed to ammonium sulphide vapour for 8 seconds prior to make gold front contacts. For the respective n- and p- Cu_2O thin film bath deposition pH values of 6.1 and 13.0 with the application of surface treatments stated above, the Cu_2O homojunction solar cell results in high photocurrent density (J_{sc}) of 12.67 mA cm⁻², open-circuit voltage of 324 mV, fill factor of 30.7% and efficiency of 1.3%.

Introduction

Solar energy is a free and abundant energy source that can be easily converted into electricity via solar cells. This is a viable solution to fulfill the existing energy demand in tropical countries since the Sun shines all over the year in such regions. Of course, commercially available solar cells are relatively very expensive for rural communities or remote regions as well as urban communities to gain this free energy source to attain their regular energy need. Consequently, development of low-cost, efficient solar cells with environmental concerns and earth abundant materials is being invigorated nowadays.

Cuprous oxide (Cu_2O) is a well-known abundant, low-cost, nontoxic, direct band gap solar energy material that can be found in both n- and p-type conductivities. Even though, this photoactive Cu_2O owes high optoelectronic properties with maximum theoretical conversion efficiency of 20%, the reported efficiencies for Cu_2O is far below. The highest efficiency for Cu_2O reported for heterojunction devices still involves expensive fabrication techniques. Apart from this, heterogeneous interfaces would produce relatively high interface discontinuities compared to homogenous interfaces. Thus, studies on fabrication of Cu_2O homojunction solar cells along with low-cost, simple, eco-friendly electrodeposition technique would be promising.

Our recent studies have shown that, the pH of the Cu_2O film deposition bath is sensitive to the relative band edge shift of Cu_2O when in contact with aqueous electrolyte or gold interfaces. Also, this observation is true for both n- and p-type electrodeposited Cu_2O thin films. Further, we have reported that the application of surface treatment also affects the shift of relative band edge positions by improving surface properties of Cu_2O thin films. Therefore, the possibility of shifting the relative band edge positions of Cu_2O homojunction was investigated varying the film deposition bath pH values of n- and p- Cu_2O thin films. Proper choice of n- and p- Cu_2O thin film deposition bath pH values, and application of surface treatments have resulted in high photocurrent density of 12.67 mA cm^{-2} , open-circuit voltage (V_{oc}) of 324 mV, fill factor (FF) of 30.7% and efficiency of 1.3% for the Cu_2O homojunction solar cell structure of Ti/n- Cu_2O /p- Cu_2O /Au.

Materials and Methods

Thin films of n- Cu_2O were potentiostatically electrodeposited on titanium (Ti) substrates in a three-electrode electrochemical cell which contained 0.1 M sodium acetate and 0.01 M cupric acetate (acetate bath). Subsequently, p- Cu_2O thin films were electrodeposited on the Ti/n- Cu_2O electrode which contained 0.4 M copper (II) sulfate, 3 M lactic acid and 4 M sodium hydroxide (lactate bath). Diluted HCl and NaOH were used to adjust the pH of both Cu_2O thin film deposition baths. Then, this bi-layer was exposed to 20% ammonium sulphide vapour for 8 seconds. Finally, a thin film of gold was sputtered onto it. The final device is shown in Figure 1. Scanning electron microscopy (SEM), current-voltage (I - V), capacitance-voltage (C - V) and spectral response measurements were implemented to analyze surface morphology and optoelectronic properties of the electrodeposited Cu_2O thin film homojunction solar cell.

Results and Discussion

Figure 2 represents the surface morphology of the Ti/n- Cu_2O /p- Cu_2O bi-layer. In comparison with previously reported SEM images of n- and p- Cu_2O

on Ti, it is clear that a thin film of p-Cu₂O has well-grown on the Ti/n-Cu₂O electrode surface.

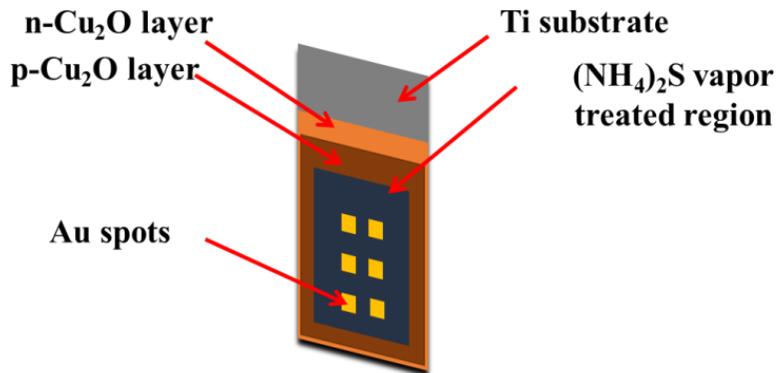


Figure 1: Schematic diagram of the electrodeposited Cu₂O thin film homojunction solar cell.

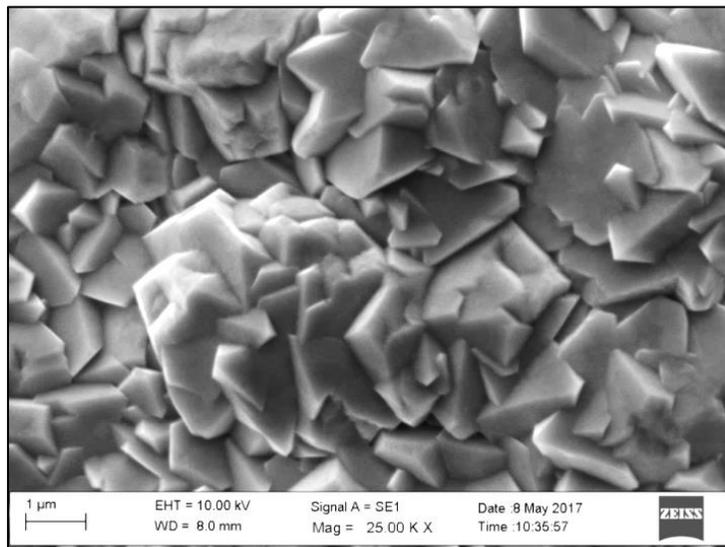


Figure 2: SEM image of Ti/n-Cu₂O/p-Cu₂O bi-layer surface.

Figure 3 shows the modulated light induced current density - voltage (*J-V*) characteristics of the homojunction solar cell where the pH values of n- and p-Cu₂O film deposition baths are 6.1 and 13.0, respectively. According to Figure 3, it is clear that the fill factor and the efficiency of the particular device are 30.7% and 1.3%, respectively. Further, spectral response of the particular device reveals that high photocurrent is resulted in the visible region of the spectrum. Also, it is clear from the *J-V* and spectral response characteristics, the poor fill factor and open-circuit voltage values may be the reasons for the

resulted low efficiency of the Cu₂O homojunction solar cell. Table 1 represents the performance of the electrodeposited Cu₂O homojunction solar cell.

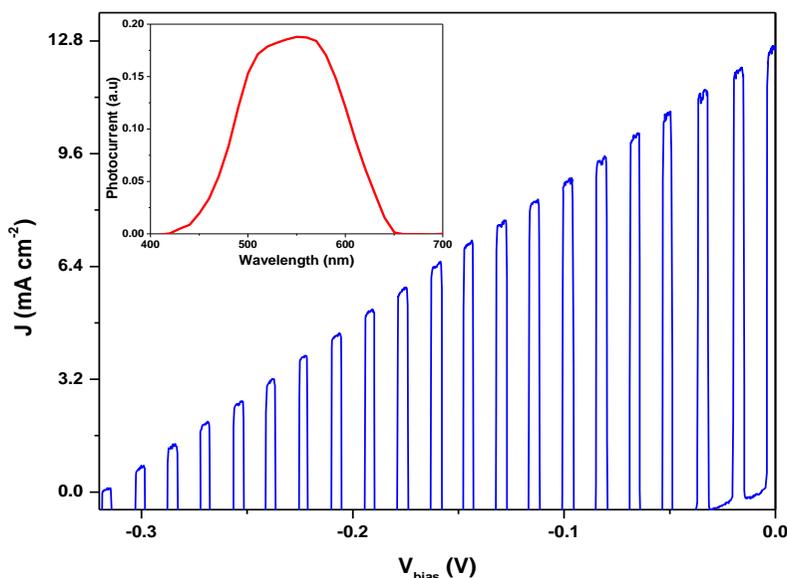


Figure 3: Modulated light induced J-V characteristics of the electrodeposited Cu₂O homojunction solar cell. Inset shows the spectral response of the same device.

Table 1: Performance of electrodeposited Cu₂O homojunction solar cell.

V_{OC} (mV)	J_{SC} (mA cm ⁻²)	FF (%)	Efficiency (%)
324	12.67	30.7	1.3

Conclusion

In this study, the possibility of improving the efficiency of Cu₂O homojunction solar cell was investigated by altering the pH value of the Cu₂O film deposition bath with the application of surface treatments to the Cu₂O thin film surfaces. High photocurrent density of 12.67 mA cm⁻² was resulted in for the respective n- and p-Cu₂O thin film bath deposition pH values of 6.1 and 13.0 with the application of surface treatments. . The reported highest short circuit current density of the homojunction Cu₂O solar cell is one of the major achievements of the study. However, the poor fill factor and open-circuit voltage values have limited efficiency of this Cu₂O homojunction solar cell, which has to be investigated further.

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Biography:



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π -Extended Push-Pull Porphyrin Dimers for Dye-Sensitized Solar Cells

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Aim and Scope

Energy demand and environment pollution are two of the most important issues for human society. Thus, the development of alternative clean and renewable energy sources is quite urgent for solving the problem of energy shortages and greenhouse effect. Among different types of renewable energy, infinite and inexhaustible solar energy is a promising candidate to meet a rapidly increasing global energy demand. In the past two decades, dye-sensitized solar cells (DSSCs) have attracted considerable attention due to several advantages, such as low production cost, feasible fabrication process and colorfulness. To date, the best power conversion efficiency (PCE) of DSSCs was reported to be ~14% by employing **SGT-021** as dye molecule [1], which is still much lower than that of commercial silicon-based solar cells (PCE ~ 25%) [2]. Therefore, improving the PCE is a crucial task for commercialized of DSSCs, a promising renewable energy source.

As a light absorber, the dye (or sensitizer) is the most important component in DSSCs. Examples of first generation of efficient dye are ruthenium-based complexes, which had achieved a PCE of 11.5% [3]. Among various ruthenium-free dyes, porphyrin-based dyes exhibit great potential for high-efficiency DSSCs. Porphyrins have intense Soret bands (400 ~ 500 nm) and moderate Q bands (500 ~ 600 nm) in the visible region [4]. Efficient porphyrin dyes, such as **YD2-o-C8**, **SM315**, **GY50**, and **SGT-021** possess donor- π -acceptor (D- π -A) architecture and long alkyl chains which respectively enhances electron injection capability of dye molecules and suppresses charge recombination process [5-7]. Accordingly, D- π -A architecture and long alkyl chains are two essential requirements for an efficient porphyrin dyes. To further improve the performance of porphyrin dyes, novel molecular designing strategy is needed. In this work, a series of porphyrin dimers, **KHH4**, **KHH5**, **KHH6** and **KHH7**, were synthesized to enhance the absorption of the porphyrin π system.

Keywords: Dye-sensitized solar cells, Porphyrin dimers, D- π -A structure.

Materials and Methods

Scheme 1 shows synthetic route of porphyrin dimers, **KHH4**, **KHH5**, **KHH6**, and **KHH7**, in which starting material porphyrin **1** and **2** were prepared as previous reported [6]. Dimerization of porphyrin monomers was performed with PIFA as oxidant to afford porphyrin dimer **3** and **5**, followed desilylation of them gave porphyrin dimer **4** and **6**, respectively. **KHH4** was obtained via Sonogashira coupling reaction of **4** and 4-iodobenzoin acid, while **KHH5**, **KHH6** and **KHH7** were prepared by the same coupling reaction with corresponding donor moiety.

Results and Discussion

UV/Vis spectra of **YD2-o-C8**, **KHH4**, **KHH5**, **KHH6** and **KHH7** are depicted in Figure1. Compared to **YD2-o-C8**, **KHH** dyes show more intense and red-shifted absorption, both broaden Soret and Q bands. These optical properties could be attributed to intramolecular excitation coupling of porphyrin dimer [8]. According to absorption spectra, **KHH** dyes have better light-harvesting capability than **YD2-o-C8**, which means that they could be a more efficient sensitizer for DSSCs.

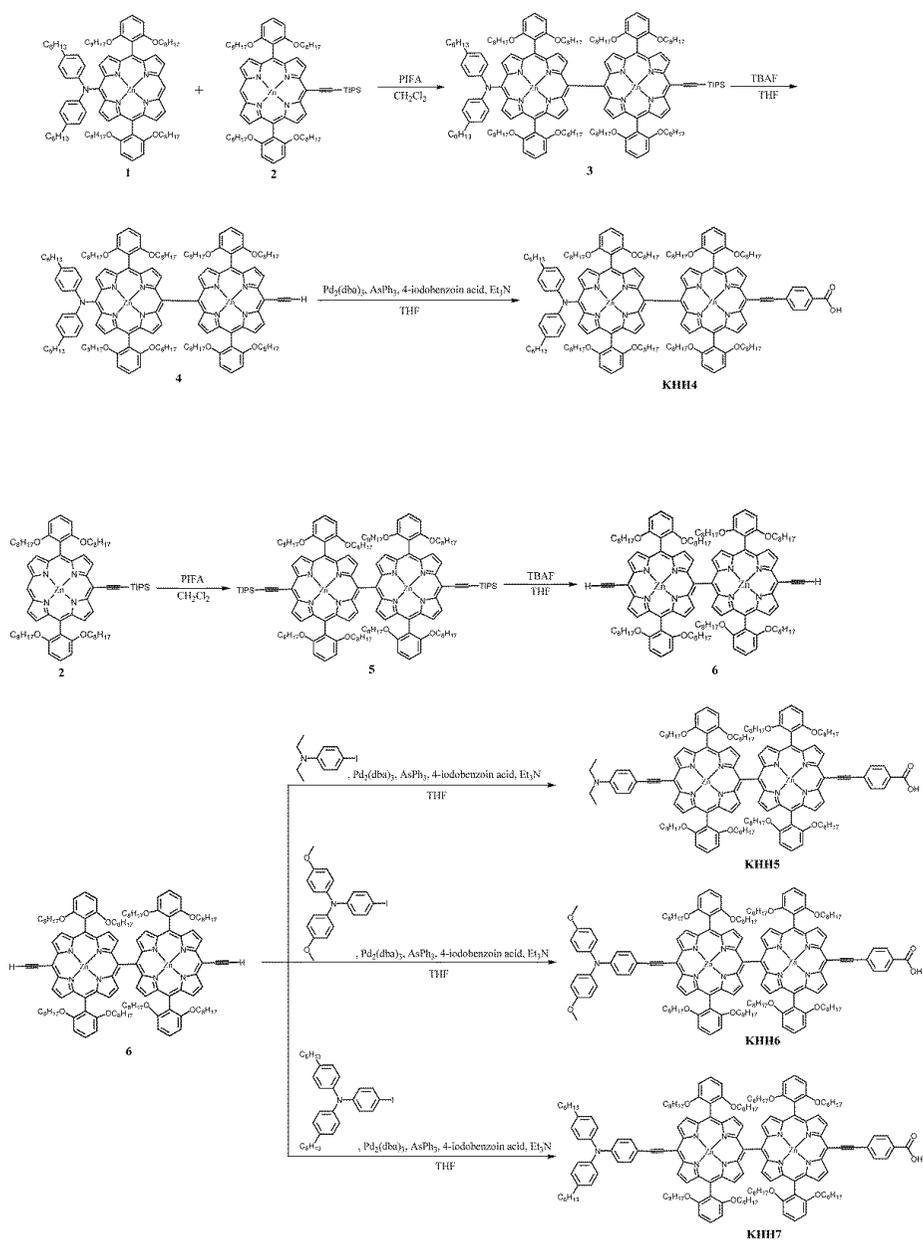
To understand HOMO/LUMO energy levels of these novel dyes, cyclic voltammetry (CV) was employed to investigate their electrochemical properties, and the results are summarized in Figure 2. Porphyrin dimers have higher HOMO and LUMO energy level than monomer, the destabilized LUMO could enhance electron injection efficiency to TiO₂ but destabilized HOMO would lower the driving force for dye regeneration. The HOMO level of **KHH** dyes is in the order of **KHH5** > **KHH6** > **KHH7**, indicating the successive electron-donating ability of different donor moieties. The HOMO-LUMO gap are almost identical for porphyrin dimers, which further supports that the broaden and red-shifted absorption spectra of porphyrin dimers arisen from intramolecular excitation coupling of them.

To examine the cell performance of **KHH** dyes, DSSCs were fabricated with **KHH4** ~ **KHH7** porphyrin dimers and the results are shown in Table 1. The PCE of porphyrin dimers (1.48% ~ 3.08%) are much lower than that of **YD2-o-C8** (11.9%), which can be mainly attributed to their poor J_{SC} . Porphyrin dimers have extended π system and larger molecular size, which could induce serious molecular aggregation, thus a decreasing J_{SC} observed.

Conclusion

A series of porphyrin dimer **KHH4** ~ **KHH7** is synthesized and employed in DSSCs in this work. As expected, porphyrin dimers have broadened and red-shifted absorption than monomer; however, the photovoltaic data of **KHH**-based cells were much lower than those of benchmark porphyrin dyes. **KHH**-based cells exhibit poor J_{SC} due to strong molecular aggregation caused by extended π system of the porphyrin dimer, to which electrochemical impedance

spectroscopy (EIS) will be employed to further understand the photovoltaic behavior.



Scheme1: Synthetic route of KHH4, KHH5, KHH6 and KHH7.

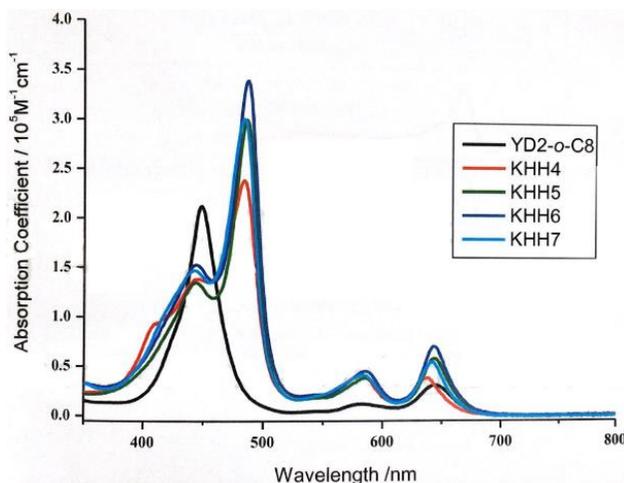


Figure 1: UV/Vis spectra of **YD2-*o*-C8**, **KHH4**, **KHH5**, **KHH6** and **KHH7**

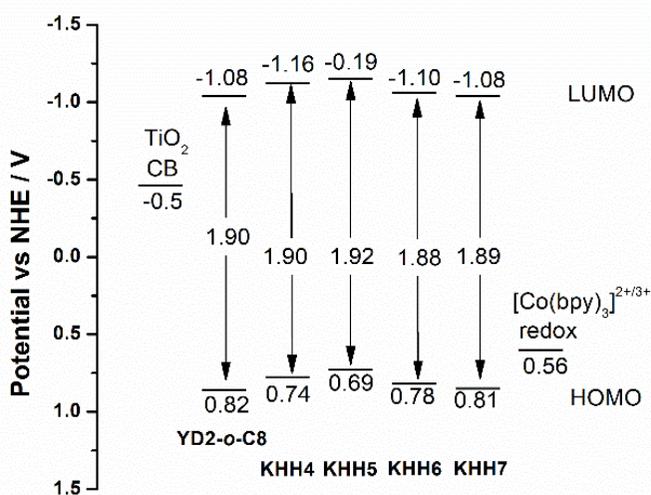


Figure 2: Schematic energy level diagram of **YD2-*o*-C8**, **KHH4**, **KHH5**, **KHH6** and **KHH7** based on their electrochemical and optical data

Table 1. Photovoltaic parameters of devices based on **KHH** dyes with $\text{Co}^{2+}/^{3+}$ -based Z959 electrolyte under AM1.5G illumination.

Dye	V_{oc} (V)	J_{sc} (mA cm^{-2})	FF	η
KHH4	0.70	6.99	0.63	3.08%
KHH5	0.70	5.56	0.69	2.67%
KHH6	0.62	3.14	0.67	1.31%
KHH7	0.64	3.47	0.67	1.48%

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Developments in Solar Cell Technology

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Abstract

The ultimate goal of renewable solar energy is aimed at developing low-cost, high-efficiency photovoltaic technologies that can satisfy the demand for future terawatt-scale solar energy. The dye-sensitized solar cells (DSSCs) with the facile assembly, cost-effectiveness, and environmental friendliness are considered to be one of the most promising candidates for next-generation solar cells. However, the typical Pt counter electrode (CE) suffers from the noble and rare nature as well as the poor stability in the electrolyte, which make it challenging for the commercialization of DSSC. Accordingly, the carbonaceous material becomes an alternative for Pt-free counter electrodes due to the multiple advantages of low cost, high electrical conductivity, high catalytic activity, and good corrosion resistance. In this talk, the working principle of DSSC will be briefly explained and followed by introducing our development of preparing a high-conductivity flexible carbon cloth with tunable catalytic activity via atomic layer deposition for counter electrode in DSSC. In the end, the advance of solid-state perovskite solar cells in our group will be shortly introduced as well.

Introduction

The DSSC is one of the electrochemical devices that involves the oxidation-reduction reactions to produce the electricity under the light illumination. While the sunlight strikes the DSSC, the photon is firstly absorbed by the dye on the TiO_2 . The excited dye adsorbed on TiO_2 is oxidized as the electron is injected into the conduction band of TiO_2 and delivered to the Pt CE via the external circuit. The reduction of triiodide into iodide is then proceeded by receiving the arrival of electron at the Pt CE. On the other hand, the oxidized dye is regenerated by the oxidation of back-diffusion iodide into triiodide to sustain the requirement of converting the light into the electricity. Accordingly, the conductivity and catalytic ability of the CE play a crucial role in achieving a high performance DSSC. Unfortunately, the traditional CE of Pt has the inherent drawback of the noble metal and its scarcity on the earth, becoming an obstacle to provide a cost-competitive DSSC. The poor corrosion resistance of Pt under the iodide-based electrolyte influences the long-term stability of DSSC, further limiting its potential of the commercialization. As a result, numerous research groups attempted to develop a variety of CEs such as

carbonaceous materials, transition metal compounds, and conductive polymers, to substitute for Pt. Among them, the utilization of carbonaceous materials as CE is particularly attractive because of the possibility of providing the multiple advantages of low cost, great catalytic activity, and high corrosion resistance. In this regard, a series of activated carbon clothes formed by the carbothermic reduction of atomic layer deposited ZnO using different ALD cycle as a nanoscale sacrificing template are prepared for a systemic study. The assembly of DSSC using a series of activated carbon clothes is then carried out to evaluate their conversion efficiency as a flexible CE.

The schematic, as shown in Figure 1, illustrates the carbothermic reduction of atomic layer deposited ZnO on carbon cloth for CE in DSSC. The ZnO was firstly deposited on the carbon cloth at the temperature of 80 °C via atomic layer deposition using diethyl zinc and water as Zn and O precursors, respectively. Afterwards, the samples of the ZnO-decorated carbon clothes with the 50, 100, 200, and 400 ALD cycles were followed by the carbothermic reaction to form a series of activated carbon clothes. The carbothermic reduction process was performed under a tube furnace at the temperature of 1000 °C for 1 h with the flow of Ar.

Methodology/Materials and Methods

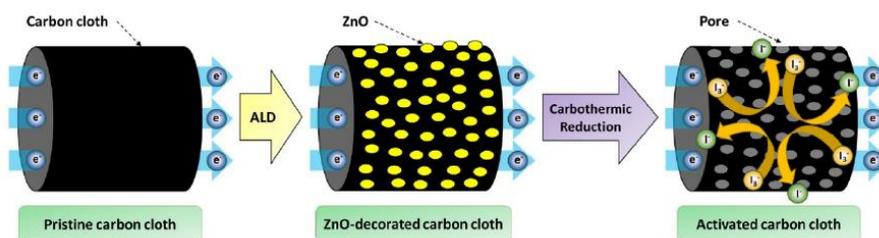


Figure 1. Preparation of activated carbon clothes.

Results and Discussion

Our result of CV analysis, as shown in Figure 2, indicates that the catalytic activity of the pristine carbon cloth can be improved after the decoration of ZnO via ALD followed by the carbothermic reduction. The sample of the activated carbon cloth via 100 ALD cycles (C-ALD-100) exhibits a best catalytic activity because of its highest J_{red} and shortest ΔE_{pp} obtained, as compared with those via different ALD cycles. Such a result can be mainly explained to the sample of C-ALD-100 with a higher surface area produced by the carbothermic reduction of high-density ZnO nanoparticles decorated on carbon cloth. In addition, the conversion efficiency of DSSCs using a CE based on pristine carbon cloth is 3.84%, which can be increased after the decoration of ZnO atop via ALD followed by the carbothermic reduction. The DSSC with a CE using

C-ALD-100 can deliver a maximum conversion efficiency of 6.88% with $J_{sc} = 14.03 \text{ mA cm}^{-2}$, $V_{oc} = 749.9 \text{ mV}$, and $FF = 65.5\%$, which is higher than that of CALD-50 (6.50%), C-ALD-200 (6.46%), and C-ALD-400 (5.93%). Even though the conversion efficiency of DSSC with a traditional Pt-based CE is 7.2%, slightly higher than that of C-ALD-100, the conversion efficiency of the CEs based on the activated carbon cloth as a function of the ALD cycles suggests the feasibility of further improving the device performance by optimizing the activated carbon cloth via the ALD cycle.

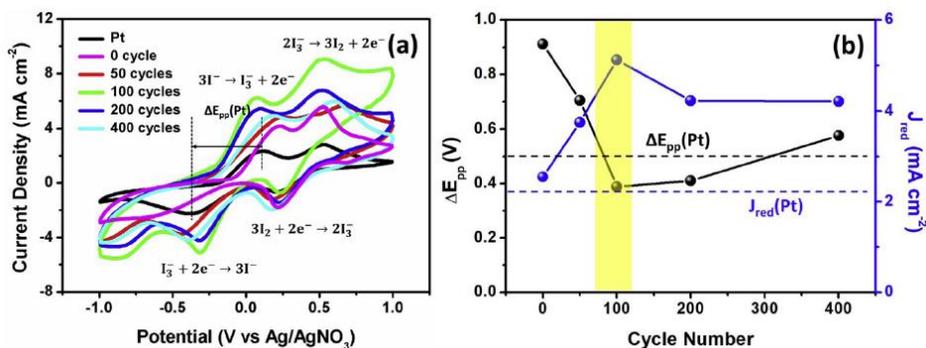


Figure 2. Cyclic voltammetry of different CEs and their corresponding peak current density and peak-to-peak separation.

Conclusions

An effective and facile route of the carbothermic reduction of ZnO via the ALD technique has been successfully developed for reaching a superior catalytic activity of high-conductivity carbon cloth as a flexible CE in DSSC. Our result reveals that the decoration of ZnO deposited on carbon cloth as a nanoscale sacrificial template during the carbothermic reaction can be precisely controlled with the ALD cycle, leading to the different activated carbon cloth. As a proof of concept, the DSSC using the activated carbon cloth via our approach can exhibit an improved conversion efficiency by 79%, as compared with that of pristine carbon cloth. In addition, the advance of solid-state perovskite solar cells in our group will be shortly introduced in this talk. More details of the above-mentioned studies can refer to our published papers.

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Biography:



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Food Waste for Treatment of Contaminated Water

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Abstract

Continuous expansion of industrial activities significantly contributes to contamination of water resources, and hence, treatment of industrial wastewater before it is discharged has become a necessity in order to manage the quality of the environment. As the existing methods for removal of pollutants have many drawbacks, alternative and more efficient methods would be of utmost importance. Use of natural biosorbents, in particular food waste, being environmentally friendly and cost-effective, has become attractive. Efficiency of pollutant removal using such biosorbents can be further improved through surface modification as the surface, once modified, displays novel properties to attract pollutants stronger. Nevertheless, many findings of such investigations are still at research level, and more efforts should be made to scale-up findings toward large-scale applications at industrial level.

Introduction

Existing methods for treatment of contaminated water include chemical precipitation, ion exchange, membrane filtration and coagulation/flocculation. These methods are associated with many undesirable aspects, such as relatively high-cost, possibility of generating large volumes of sludge and environmentally unfriendliness. On the other hand, adsorption methods offer advantages over the other techniques with regard to removal of pollutants from wastewater due to its simple design, low-cost adsorbents, ease of regeneration, adequacy of limited space, requirement of small adsorbent mass and minimal sludge formation [1,2]. This method has also been found to be efficient as the treated water is of higher quality without the production of secondary hazardous pollutants. Various adsorbents have been studied in the treatment of wastewater, such as waste from fruits, vegetables and leaves, including jackfruit core, jackfruit skin, breadfruit core, breadfruit skin, durian seeds, dragon fruit skin, bitter melon seeds, watermelon seeds and rice husk [3-6]. Nevertheless, the search for better and more effective adsorbents has been an on-going quest [7]. In recent years, synthesized adsorbents and modified natural biosorbents have also been researched upon in the hope to enhance adsorption capacity and to extend life-time of unmodified adsorbents [8-10].

This paper provides a brief review on the findings of adsorption capabilities of selected types of biosorbents, in particular food waste, toward heavy metal ions and industrial dyes, and possibility of extending laboratory-based findings toward applications.

Materials and Methods

Preparation of samples

A bulk sample of selected biosorbents was collected, washed, dried and ground them to obtain particles of desired sizes. To find the most suitable treatment method, the samples were treated with acid (e.g. HNO₃, HCl, CH₃COOH), bases (e.g. NaOH), complexing agents (e.g. Ethylenediaminetetraacetic acid - EDTA), surfactants (e.g. sodium dodecylsulafte – SDS) and salts (e.g. NaCl, KCl) allowing for pre-determined stirring time and settling time periods. Thereafter, treated biosorbent samples were washed thoroughly with tap water followed by distilled water until the pH of washings was equal to that of water used for rinsing. Samples thus prepared were stored in dry under ambient conditions for further experiments. Analytical grade reagents were used to prepare respective standard solutions in distilled water. The pH of solutions was adjusted using 0.1 M NaOH and/or 0.1 M HNO₃ solutions, as necessary.

Instrumentation

The total concentration of metal ions in all solutions was determined using atomic absorption spectrophotometer (AAS), while that of dyes was determined using a UV/Visible spectrophotometer.

Research methodology

Optimization of experimental parameters, such as biosorbent dosage, shaking time, settling time and solution pH, under static conditions was determined using 50.0 mL aliquots each adsorbate solution by changing one parameter at a time within a reasonable range. Once the process of optimizing a certain parameter was complete, another parameter was optimized keeping the already optimized parameter unchanged. This process was continued for all parameters. Subsequent experiments were performed under optimized parameters whenever possible. The removal efficiency of each adsorbate was calculated using the Equation (1),

$$\text{Removal percentage} = \frac{C_0 - C_f}{C_0} \times 100 \quad (1)$$

where C_0 is the initial concentration of metal ion in solution phase and C_f is the final concentration of adsorbate in solution phase.

Under optimum conditions, adsorption experiments were carried out for different concentrations of adsorbates within a broad range after adsorption

equilibrium was established, to investigate adsorption isotherms. The mass of adsorbate adsorbed per unit mass of the biosorbent is given by Equation (2)

$$q_e = \frac{(C_0 - C_f)V}{m} \quad (2)$$

where q_e is the metal uptake (mg kg^{-1}), and V (L) and m (kg) are the solution volume and mass of the adsorbent, respectively. Scaling up of laboratory batch studies toward large-scale dynamic experiments was performed using glass columns packed with biosorbents in unmodified or modified forms.

Results and Discussion

Table 1 summarizes the adsorption capacity of selected industrial dyes, namely, malachite green, methyl violet 2B and crystal violet, and selected metal ions, namely Cr(III) and Ni(II) with unmodified and modified biosorbents. It is clear from the results that significant improvement of adsorption capacity of jackfruit skin biosorbent is resulted in when the biosorbent is treated with EDTA, due to chelating ability of the adsorbed EDTA reagent to trap metal ions. Improvement of adsorption capacity of NaOH-treated jackfruit skin and wild breadfruit skin toward the above metal ions can be attributed to deprotonation of carboxylic, alcohol or phenolic groups leading to stronger attraction with positively charged metal ions. On the other hand, HNO_3 treatment of jackfruit skin biosorbent also shows enhancement of adsorption of the above metal ions to some extent, probably due to exchange of such ions with H^+ ions that could be present in the protonated biosorbent. It is thus evident that metal ion – biosorbent systems are so complex that many types of mass transfer modes, such as adsorption, absorption, ion-exchange, and transfer to micro and macro pores would be possible. Moreover, pH dependence and interference effects would make the situation even more complex.



Figure 1: Column experiments of *Artocarpus nobilis* biosorbent

Table 1: Adsorption capacity of biosorbents toward metal ions and industrial dyes.

Biosorbent	Adsorbate	Modifying agent	Capacity (mg/g)
Tarap (<i>Artocarpus odoratissimus</i>) skin	Malachite green	No treatment	80.5
		SDS	100.8
		EDTA	116.8
		NaOH	157.6
Jackfruit (<i>Artocarpus heterophyllus</i>) skin	Cr(III)	No treatment	13.5
		SDS	26.2
		EDTA	41.7
		NaOH	37.0
	Ni(II)	HNO ₃	25.2
		No treatment	12.0
		SDS	20.9
		EDTA	52.1
Rock melon (<i>Cucumis melo</i> var.) skin	Methyl violet 2B	NaOH	27.2
		HNO ₃	21.9
<i>Artocarpus camansi</i> peel	Crystal violet	No treatment	224.6
		NaOH	669.7
Wild breadfruit (<i>Artocarpus nobilis</i>) peel	Ni(II)	No treatment	275.0
		NaOH	479.0
Pomelo (<i>Citrus grandis</i>) leaves	Methyl violet	Washed peel	13.2
		NaOH	14.9
<i>Artocarpus odoratissimus</i> leaves	Methyl violet 2B	No treatment	248.2
		NaOH	910.8
<i>Artocarpus odoratissimus</i> leaves	Methyl violet 2B	No treatment	139.7
		NaOH	1004.3

Extent of adsorption of dyes is much improved upon treatment of biosorbents with NaOH reagent. This is attributed to stronger attraction of negatively charged functional groups formed by deprotonation when biosorbent is treated with NaOH with cationic dye molecules.

Scaling-up of static experiments performed by passing of adsorbate solutions through columns packed with biosorbents results in positive results (Figure 1). The next logical step would be to investigate ability of removal of pollutants in proto-type systems, which is underway at present.

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efficiency of crystal violet dye from colored wastewaters: insights into equilibrium, adsorption mechanism, and reusability" *Int. J. Phytoremediation*, 1–11. (2020)

Biography:



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A Review of Heavy Metals in Urban Dust in Major Cities of Sri Lanka

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Abstract

Due to the air pollution in the world, several environmental health issues have been reported. Particulate matter, gases and organic compounds and ambient air are the most common types of air pollutants encountered in urban areas. Despite dust being a major air pollutant, identification of dust sources and understanding of their chemical processes with the prevailing environmental setting is a challenging task. Dust in urban areas can be generated due to automobile activities, basement soil, pavement abrasion, construction works and other anthropogenic activities. Even though Sri Lanka is a developing country with less commercial and industrial activities, the concentrations of HM in dust are comparable with the major cities in the world. Elevated levels of HM in dust are mainly due to anthropogenic sources such as vehicular traffic, poor urban waste management and domestic emissions. Prevailing natural conditions such as wind action, morphological setting, tropical climatic conditions and some soils rich in HM are also contribute for HM accumulation. Transboundary effects from India and Arabian Peninsula may also influence the dust accumulation of Sri Lanka. With the unique settings and inherited natural processes of each city, understanding of cycling of HM in urban environments of Sri Lanka is complicated. Poor city dwellers are more vulnerable to dust pollution, which can lead to health, social and economic problems in the future.

Key words: Dust, heavy metals, major cities, pollution, review.

Introduction

Dust is one of the major pollutants in the urban environments. Further, it acts as a medium for spreading of other toxic materials in the urban environment and its surroundings. Deposited materials in dust are mostly air pollutants which affect heavily on socioeconomic status and health problems of the society. Heavy metals can be accumulated into dust due to several sources, such as automobile traffic, deterioration of building, construction activities and corrosion of metal constructions as well as industrial activities in the urban environment. Heavy metals are one of the major contaminants in the environments, and the accumulation of them has been increased by

anthropogenic sources. Understanding of sources and accumulation processes of heavy metals and metal uptake into the urban dust in Sri Lanka would be useful for other developing countries situated in tropical climatic conditions.

The objective of this review is to summarize on factors influencing for enrichment of heavy metals in road and house hold dust of two major cities in Sri Lanka (Figure1) due to natural and anthropogenic processes based on the recent literature and unpublished data from the authors' laboratory.

Materials and Methods

Acid digestion of 0.1 g of sieved samples was done by microwave digestion method using HNO₃, HClO₄ and HF (HNO₃:HClO₄:HF = 7:2:1). Concentrations of Cu, Zn, Pb, Fe and Ca in acid digested samples were measured on flame atomic absorption spectrophotometer (AAS, Varian AA240FS) at the Department of Geology, University of Peradeniya, Sri Lanka.

Results and Discussion

Statistical analysis of all available data [1 – 4] confirms that both road dust and house hold dust have comparable values in terms of several elements. The average concentrations of measured elements in dust have been increased with the time (Table 1), and the assessed values of them in the recent past are comparable to those in other major cities in the world. Dry and wet atmospheric deposition of heavy metals with relatively high concentrations in Kandy city (Table 2) can be attributed to be primarily originating from traffic sources [5]. Despite Kandy being a small city, the content of heavy metals in dust is relatively high compared to those in Colombo, the capital of the country. The most abundant element in all the samples from Colombo is Fe, which is a common element in the basement lateritic soil in the area. Concentrations of Ca in dust of both cities are higher than the background levels, indicating the input of construction materials into dust. The concentrations of Zn and Cu levels Sri Lankan dust are higher than those of other measured heavy metals, and it may be due to automobile traffic and corrosion of metallic materials. Statistical analysis reveals that road dust is more polluted than road deposited sediments in terms of several heavy metals. According to geo-accumulation index, road dust is moderate to strongly polluted, and road deposited sediments are moderately polluted. Higher pollution conditions of road dust may be due to the re-suspension of dust particles. Long-range transboundary air pollution is another source of some metals due to their persistence and potential for global atmospheric transfer, and atmospheric emissions affect even the most remote regions [6]. Despite unleaded petroleum is used for the vehicles, the Pb level has been increased with time in the recent past.

Major and trace element data imply that urban dust of Sri Lanka may have been derived from the basement. However, the chemical composition of them has been altered by anthropogenic processes. Since the country does not

have large scale industries, it can be assumed that the major anthropogenic sources of heavy metal polluted dust are automobile traffic in the urban environment, urban waste, and weathering and corrosion of built materials. However, prevailing tropical climatic conditions, basement soil composition have been concealed the instinctive composition of urban dust. Therefore, understanding of accumulation of heavy metals into dust is a controversial issue.



Figure 1: Map showing location of two major cities of Sri Lanka.

Table 1: Comparison of mean concentrations (mg/kg) of heavy metals in dust in major cities of Sri Lanka with time.

Reference	Year	City	Average concentration (ppm)				
			Pb	Cu	Zn	Ca	Fe
Pitawala et al., 2013	2013	Colombo	2	3	28	3000	95000
Herath et al., 2016	2016	Colombo	23	180	349	n.m.	39600
Pitawala et al., 2013	2013	Kandy	5	94	611	40000	36000
Samaradiwakara and Pitawala,	u.p.	Kandy	49	319	775	48516	40347

n.m. – Not measured, u.p. – unpublished

Table 2: Mean concentrations ($\text{mg m}^{-2} \text{day}^{-1}$) of HM in dry (A) and wet (B) depositions (Weerasundara et al., 2017).

Element	Mean concentration ($\text{mg m}^{-2} \text{day}^{-1}$)	
	A	B
Al	46	54
Cr	0.3	0.3
Mn	1	1.2
Fe	66	94
Ni	0.2	0.2
Cu	0.3	0.5
Zn	4.4	8.4
Cd	0.04	0.06
Pb	0.3	0.4

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Biography:



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In situ phase inversion emulsification and biological for highly efficient remediation of sediments contaminated by persistent organic pollutants

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Abstract

Environmental remediation, such as remediation of persistent organic pollutants (POPs) and chlorinated solvents, is an important research area in the past four decades in environmental engineering. The toxicity of these contaminants has negatively impacted the ecosystem and affected human health. To solve this problem, our team developed a technology integrating *in situ* phase inversion emulsification and biological reductive dechlorination (ISPIE/BiRD) for highly efficient remediation of chlorinated POPs in river sediments and soils. Within 70 days, the polychlorobiphenyls (PCBs) and hexachlorobenzene (HCB) in river sediment have been removed more than 98% in a field pilot study. Similarly, in a 28-day sandbox study, DDT has been successfully removed more than 99.0%. This high removal was achieved by simultaneously thermally enhanced mass removal through ISPIE and heat selection of indigenous microbial community. This heat selection strategy was also applied to the biodegradation of TCE in a simulated groundwater and showed more than 70 folds improvement on biodegradation rate. The key to this success lies in the structural reengineering of microbial community and now it is termed microbiome reengineering (MBRE). This technology showed high feasibility in environmental remediation across at least three different environmental matrices, *i.e.*, sediments, soils, and groundwater.

Introduction

MBRE is developed from ISPIE/BiRD. Thus, ISPIE/BiRD is briefly introduced below. ISPIE/BiRD is originally designed for rapid bioremediation of POPs, such as PCBs and HCB, present in river sediments. There are three obstacles: slow desorption, low water solubility and slow biodegradation rate. The first two can be solved by increasing the temperature but may cause negative impact on the microbial community. ISPIE/BiRD involves heating an emulsion made of nonionic surfactants that can cause phase inversion, forming a water-in-oil (W/O) emulsion (Figure 1). Since the hot W/O emulsion exhibits typical hydrophobic behavior in the sediment pore, it has higher opportunity to contact the hydrophobic POPs. The elevated temperature can also increase the desorption rate, rapidly repartitioning into the oil phase, as well as elevating the

water solubility of POPs [1,2]. This technology was also successfully applied to soils contaminated by lindane and DDT later [3].

Methodology/Materials and Methods

ISPIE/Bird in sediment remediation: Both laboratory study and field pilot study were performed. In the laboratory study, a batch biodegradation test was conducted following the Taguchi method to define the optimum environmental parameters for field pilot study. A column study was also performed to test the effectiveness of ISPIE/BiRD in a simulated sediment. Later, these parameters were applied to a field pilot study in the sediment of the Er-Ren River. Eight different conditions were tested on both the freshly added and weathered PCBs and HCB. Next-generation sequencing (NGS) was applied to the pilot study samples.

ISPIE/Bird in soil remediation: For this study, a batch test, a column test, and a sandbox test were performed. In the batch test, the Taguchi method was applied to define optimum environmental parameters. A column test was implemented employing real agricultural soil to determine the recovery efficiency of a single ISPIE operation on lindane and DDT. A sandbox study was performed to observe the enhancing effects of residual emulsion in soils on the biodegradation. Microbial DNAs were sampled for NGS to profile the microbial community.

MBRE in a TCE-contaminated groundwater: A batch study was performed to test the enhancing effects by heat selection on a mixed microbial culture from a contaminated groundwater. Eight different heat selection conditions were applied and the microbial culture were then kept under room temperature in a modified yeast extract medium. The samples in this batch study were sampled on the first and second day.

Results and Discussion

Lab study in sediment remediation: The results were as shown in Table 1. Among all test combinations, Group 7 showed the best removal for both of PCBs and HCB. Considering both contaminants, the optimum conditions were 30 °C, 10% emulsion concentration, 1.0% high organic matter, and a pH range of 7.0 to 8.5. It indicated that HCB can be removed much faster and the ratio are quite consistent. The curve-fitting by using Arrhenius equation showed that the activation energy of PCB was about 3.3 time higher than that of HCB and HCB degradation is more temperature dependent.

Pilot study in sediment remediation: The ISPIE operation only rendered about 50% removal. The variation of HCB was quite large and the freshly added ones showed better and more even results. For the BiRD stage, it was evident that weathered ones showed higher removals than the fresh ones for both PCBs and HCB. For the overall ISPIE/BiRD process, for the weathered PCBs, the

removals for WNR and WBA were over 98.0% while these removals of weathered HCB in WNR, WBS, and WBA were all 100% (Figure 2).

Microbial community profiles in pilot study: The traditionally highly related dechlorinating bacteria and archaea behaved very differently. For example, no. 2, 6, and 7 under *Chloroflexi* phylum were often found in dechlorination consortia but showed highly negative correlation with the removal rates based the negative slopes. *Methanosaeta* spp. showed highly positive correlations with the removal rates but were not among the famous dechlorinating ones.

ISPIE/Bird in soil remediation: The results showed that water content and emulsion concentration are the most critical controlling factors, and the removal rates of lindane and DDT was 99.7% and 88.9%, respectively. A single operation of ISPIE removed 52.9% and 31.5% of DDT and lindane, respectively, and the difference is probably due to the log K_{ow} . The best parameter combination was employed in the sandbox test and the best removal rates of lindane and DDT on the 28th day were $78.0 \pm 1.2\%$ and $99.7 \pm 0.5\%$, respectively. NGS data results showed that agriculture soil has more abundant and diverse microorganisms. NGS analysis showed two cohesive groups were competing against each other in the batch test and complex interactions existed in the sandbox test. (Chang et al., 2021)

MBRE in TEC biodegradation: Due to the success in the MBRE in sediment remediation, a mixed culture from a TCE-contaminated site was used for a heat selection test. Currently, the results are under review for paper publication and thus the details cannot be provided here. However, it has been confirmed that the heat selection did increase the biodegradation rates. The half-life of TCE biodegradation was the shortest in the literature. Thus, MBRE has very high potential to be applied to field remediation.

Table 1: Biodegradation kinetic parameters of HCB and Aroclor 1254 (Chang et al., 2019a)

No	HCB				Aroclor 1254				k_{HCB}/k_{PCB}
	k (day ⁻¹)	R^2	$t_{1/2}$ (d)	Rank	k (day ⁻¹)	R^2	$t_{1/2}$ (d)	Rank	
1	0.0131	0.9435	52.9	9	0.0044	0.9053	156.9	9	2.97
2	0.0176	0.8985	39.4	8	0.0079	0.9005	87.5	8	2.22
3	0.0224	0.9806	30.9	7	0.0104	0.9377	66.3	7	2.15
4	0.0326	0.9941	21.2	5	0.0118	0.9316	58.5	6	2.76
5	0.0371	0.9990	18.7	4	0.0147	0.9669	47.0	3	2.51
6	0.0261	0.9797	26.6	6	0.0122	0.9910	56.9	5	2.14
7	0.0490	0.9884	14.1	1	0.0179	0.9921	38.7	1	2.74
8	0.0374	0.9951	18.6	3	0.0123	0.9291	56.5	4	3.04
9	0.0438	0.9846	15.8	2	0.0155	0.9702	44.6	2	2.82

Conclusions and Recommendations

With the advocates of green sustainable remediation, bioremediation application has increased in recent years. The MBRE technology has the potential to become a mainstream bioremediation technology apart from biostimulation and bioaugmentation. It is recommended that MBRE should be tested in different environmental matrices, different contaminants, and different cultures.

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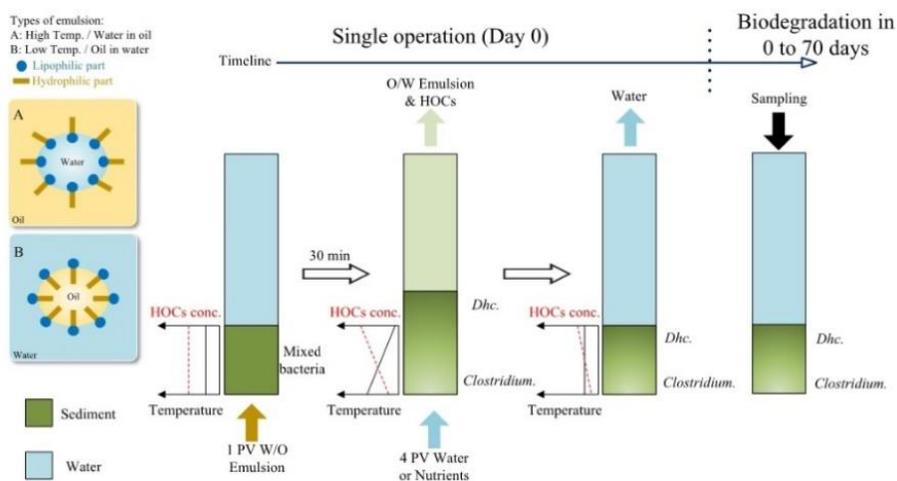


Figure 1 The schematic presentation of ISPIE/BiRD

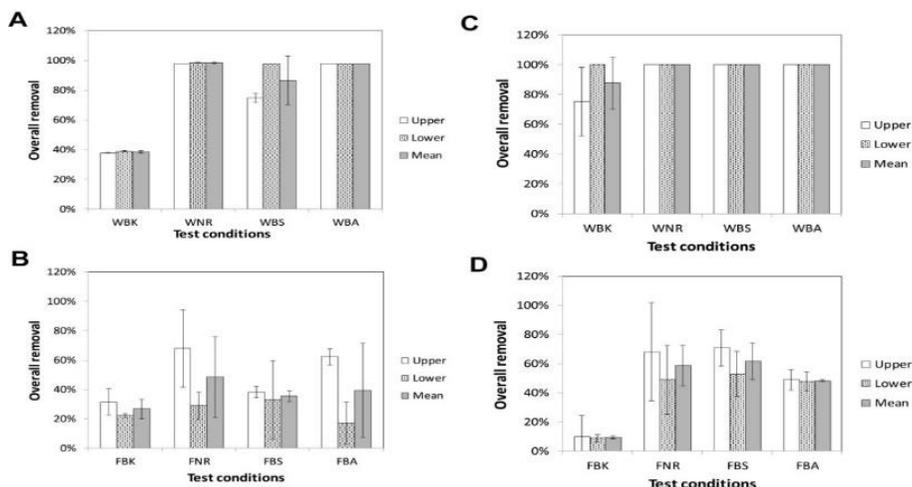


Figure 2 The total ISPIE/BiRD removal of weathered Aroclor 1254(a), fresh Aroclor 1254(b), weathered HCB(c) and fresh HCB(d) (Chang et al., 2019b).

Biography:



Dr. Shu-Chi Chang obtained his bachelor degree from National Cheng Kung University in Taiwan and master and doctoral degrees from the University of Michigan at Ann Arbor, USA. His research interest lies in integrated remediation of contaminated soils, sediments, and groundwater; circular economy through vitrification of contaminated sediments, soils, and sludges; and microbiome reengineering for rapid biodegradation. He is now an associate professor and

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Electrical Energy Storage Development in Taiwan

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Abstract

The energy policy of Taiwan government is to target the generation of 20% of electric energy from renewable energy. To maintain a stable power grid, energy storage becomes important. Lithium-ion battery (LiB) and all vanadium redox flow battery (VRFB) are two major energy storage technologies. Several demonstration sites of LiB and VRFB were installed and were under evaluation. Operating experience and evaluation results will be beneficial for future energy storage development in Taiwan.

Introduction

Taiwan Executive Yuan has introduced a 5+2 innovative industries program. This program is aiming to transform and upgrade Taiwan traditional industries and to make industries more competitively in the global market. Those programs include intelligent machining, Asia Silicon Valley, biomedicine, green energy, defense and aerospace, new agriculture and circular economy. On the green energy program, 20% of the electricity will be replaced by renewable energies, such as 20 GW of solar energy, 6.7 GW of wind energy, before 2025. By 2019, about 6% of Taiwan electricity has been generated by renewable energy whereas 5.5 GWh from hydro, 1.8 GWh from wind power, and 4.0 GWh from solar photo voltaic. Photovoltaic and wind turbine generates intermittent electric energy and impact electric grid when large portion of electricity is generated by them. Energy storage becomes necessary to maintain power grid quality and energy management.

Energy Storage Technology

The most popular energy storage is pump hydro due to low-cost (100-300 USD/kWh) and long service life (> 30 years). About 98% of the global electricity storage is pump hydro. It stores the electricity as the potential energy. Pump hydro pumps water from lower reservoir to upper reservoir using excess electricity and release electricity by water flowing from upper reservoir to lower reservoir through a water turbine and power generator. A 2 GW pump hydro plant located at central Taiwan is served this purpose. Pumped hydro is limited by geographic location and is not feasible for local distributed energy storage in the city or near by the wind farm.

Batteries is a potential candidate for distributed energy storage due to their high energy density (> 20 Wh kg⁻¹) as compared to pumped hydro (< 1 Wh kg⁻¹) as shown in Figure 1. Metal air batteries are potential for next generation

energy storage due to extremely high energy density and metals are abundance in earth crust (Al and Mg). However, ability of recharging and cycle life are technical barriers to be overcome. Many types of battery have been demonstrated as energy storage in MW level. They are lead acid battery, nickel metal hydride battery, lithium-ion battery (LiB), sodium-sulfite battery and redox flow battery. Hydrogen fuel cell is also considered as an energy storage device. LiB has been widely used in portable electronics and electric transportations, such as electric scooter and electric vehicle. Now LiB is used in many energy storage demonstration sites in couple with photovoltaic and wind turbine power plants. All vanadium redox flow battery (VRFB) is also considered for energy storage applications due to its safety, long cycle life, and reliable features. As given in Figure 2, vanadium ions (V^{2+} , V^{3+}) and vanadium oxoions (VO^{2+} , VO_2^+) are stored at the positive and negative electrolyte tank, respectively. They circulated through the cell stack by circulation pump. During discharging cycle, reaction $VO_2^+ + 2 H^+ + e^- \rightarrow VO^{2+} + H_2O$ and $V^{2+} \rightarrow V^{3+} + e^-$ are taking place on the positive and negative electrode, respectively. During charging cycle, those reactions are reversed.

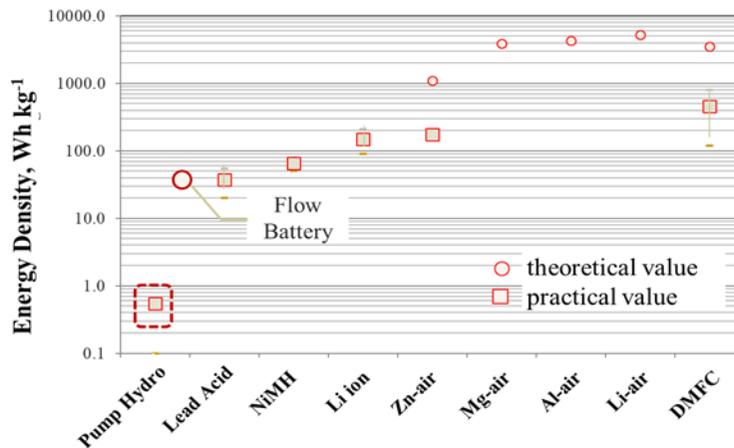


Figure 1: Energy density of different batteries as compared to pumped hydro.

Taiwan Energy Storage

At present, about 6% of electricity generated in Taiwan is generated by renewable energy. The impact of renewable energy on power grid is not significant. However, the impact would be significant in the near future when more than 20% of electric energy is generated from renewable energy. Several LiB demonstrations have been installed and operated. Two 1 MW/MWh energy storages have been installed at Yongan Kaohsiung and Longjing Taichung (Figure 3), respectively. These energy storages are operated in coupled with wind farm and solar farm, respectively. A 2 MW energy storage for power regulation was installed at Kinmen in 2020. A 1 MW energy storage was also

installed at National Changhua University of Education. Recently, five MW-level LiB energy storages are under construction for automatic frequency control (AFC) of local power grid. On the VRFB development, Taiwan power company is the first organization installed and tested VRFB in commercial scale, 125 kW/700 kWh VRFB (Figure 4 left). China petroleum Co. was also installed VRFB at two of their scooter charging stations. A 42 kW VRFB was installed at National United university (Figure 4 right). This VRFB will be acted as a power buffering for the scooter charging station.

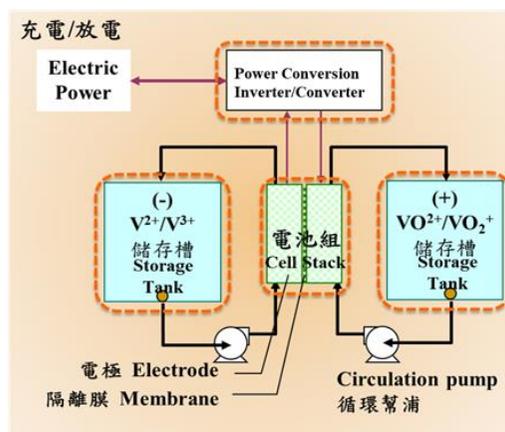


Figure 2: Schematic diagram of all vanadium redox flow battery.

Conclusion

Despite the installation of renewable energy will continue to grow, the energy storage is not required in the power grid in near future. However, both LiB and VRFB energy storages were installed and tested at different sites for various applications in Taiwan. The pro and cons of each technology will be evaluated. Operation experience and evaluation results will be beneficial for future development of energy storage in Taiwan.



Figure 3: Demonstration site of photovoltaic plant in coupled with a 1MW/1 MWh lithium battery at Taichung, Longjing.



Figure 4: Redox flow batteries demonstration site. Left photo 125 kW/700 kWh VRFB at Taipower research laboratory. Right photo 42 kW at National United University.

Biography:



Prof. Kan-Lin Hsueh obtained his Ph.D. in Chemical Engineering from Clarkson University, USA, in 1983. He joined the Chem. Eng. Dept., National Tsing Hua University as an Associate Professor in 1984-1989. He worked for AMP Inc. USA, as a researcher in 1989-2000 and for NanoSciences Corp. USA, in 2000-2001. He served as a researcher and later as a Lab manager for Industrial Technology Research Institute in 2001-2007. In 2008, he joined the Department of Energy Engineering, National United University. Now he is

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Emerging Trends in Green Building Design: Green Walls as a Compelling Architectural Element for Sustainable Contemporary Cities

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Abstract

Living wall systems are one of the popular elements in current architectural practice, and they regulate microclimatic impacts whilst adding an attractive esthetic value to a building. The plants in living walls can act as a thermal barrier in reducing the overall temperature, which would in turn reduce the cooling load requirements for buildings. Various parameters of the selected plant species in living walls may influence differently on their thermal performance. The present experimental study examined the impact of leaves density of living walls for their thermal performance by using ten identical experimental cubical wall structures (1 m × 1 m × 1 m) representing 8 living walls of 4 species with 2 replicates and 2 control experiments oriented to the south direction. A bare wall constructed with cement blocks has been used as the control experiment while *Asparagus aethiopicus*, *Xiphidium caeruleum*, *Ophiopogon japonicus* and *Dianella ensifolia variegata* have been used as the species of living wall experiments setups that represent various leaves densities. Data collection was conducted from 9:00 a.m. to 6:00 p.m. for a period of one week in August 2019, by recording the ambient temperature and relative humidity, wind speed and living wall and bare wall surface temperatures. The imageJ software was used to calculate the pixels of the binary images, which represented the area covered by plants, thereby estimating the leaves density of the living walls.

Introduction

World's arable lands are rapidly transforming into cities where the built environment is accounted to be responsible for 75% of the world's annual greenhouse gas emissions. Buildings are solely accountable for 39% out of these emissions, which has incontrovertible impacts for the environment and human health [1, 2]. Apart from the alarming repercussions on climate change, the rising levels of indoor and outdoor pollutants are adversely affecting human longevity by creating permanent health impacts such as decreasing lung capacity and diseases such as asthma and bronchitis [3]. Even though trees and vegetation could play a major role in alleviating these environmental stresses, there exists a need to reevaluate the ways of incorporating elements that recreate nature into modern cities. One major reason for the difficulties in integrating the urban green space into cities is the limited space available in-

built environment. Especially, the percentage imperviousness in urban land use is quite high and the space available for green landscape is considerably limited in such areas [4]. One of the solutions architects and engineers have recommended in addressing this issue is to incorporate green features to the building envelope itself. In recent years, green walls have become one of the most popular and vibrant ways to incorporate plants and greenery into buildings, within its interior and exterior [5].

Although a considerable amount of studies on green walls have been reported, studies on the effects of leaves density on the performance of green walls with respect to the different plant species and their characteristics is not much. Moreover, there are limited studies conducted yet in Sri Lanka with respect to the local climatic conditions, to identify the relationships between the building energy performance and the leaves density of the plant species. Therefore, the present study focuses on understanding the impact of leaves density of the living wall plant species on the building energy performance.

Materials and Methods

Ten identical, movable cubical structures were built on the roof top of the 5-story building in the Faculty of Applied Sciences, University of Sri Jayewardenepura premises, which was an open area without any disturbances from the shading from adjacent buildings or trees. The basic structure with the dimensions of $1\text{ m} \times 1\text{ m} \times 1\text{ m}$ was initially prepared from steel. The $1\text{ m} \times 1\text{ m}$ concrete wall was built to cover only a side of the cubical structure. The exposed sides were covered using plywood sheets with the thickness of 0.5" and then insulated with double-sided McFoil of 25 mm thickness. Two openings were made on the plywood sheets which were opposite to one another and adjacent to the built wall to aid the measurement of interior data and were kept closed during the remaining period. All the 10 walls were intended to simulate building walls. Two bare walls were used as the control experiment. For the living wall systems, a white color geotextile felt was attached to the built concrete wall with 36 pockets in each. The setups were oriented to South direction.

Four plant species were selected which are of the same family and have similar water stress. Each experimental setup represented two replicates for each and 36 plants were included for a single living wall. Two bare walls constructed with solid cement blocks were used as controls. To apply similar conditions to the selected plants, a growth media which consisted of coir dust, sand and compost was used at 1:1:1 ratio for all the plants. After installing all the plants into the geotextile pockets, they were kept in the location for two weeks to adjust themselves to the newly introduced environmental condition, prior to the data collection. As water can affect the measurements, water was incorporated into all the setups in similar amounts by watering them every day in the morning before starting the data collection for that day. All the plant species selected for this study had similar water stresses and therefore, it has

been ensured that the moisture generated from watering of the plants has been neutralized for all the experiments.

Results and Discussion

In the present study, the effect of leaves density of the living walls has been observed for the building energy performance. Leaves density has been calculated and the results have been compared with the obtained heat flux results in Table 1.

Table 1: Comparison of net heat flux values and leaves density of bare wall and living walls.

	<i>Xiphidium caeruleum</i> (W m ⁻²)	<i>Asparagus aethiopicus</i> (W m ⁻²)	<i>Ophiopogon japonicas</i> (W m ⁻²)	<i>Dianella ensifolia variegata</i> (W m ⁻²)
Heat flux	-29.37	-32.41	-25.36	-23.76
Leaves density	59.35%	68.58%	45.14%	80.01%

Even though the leaves density differs among the four-plant species, the living wall with *Dianella ensifolia variegata* shows the maximum coverage of the bare wall while recording the minimum incoming heat flux. The leaves density of other living walls has been fluctuated due to differences in the growth of the plant species and external factors. The minimum leaves density is for the living wall with *Ophiopogon japonicas* and the incoming heat flux is comparatively lower than the other species. However, the maximum incoming heat flux is for the living wall with *Asparagus aethiopicus* which has the second-highest leaves density. Spearman coefficient was used to assess the correlations between the heat flux and leaf density. The leaves density and heat flux showed a moderately negative correlation ($r = -0.5$, $p < 0.05$) indicating that the heat flux to the wall from the ambient environment decreases with the increasing leaves density. Despite having a higher leaves density, unlike the living wall with *Dianella ensifolia variegata*, the maximum heat flux is recorded by the living wall with *Xiphidium caeruleum*.

Conclusions and Recommendations

Among the four-plant species selected for the experiment, the living wall with *Asparagus aethiopicus* has contributed more to the building energy savings with a higher leaves density. Since this contribution may integrate the influence of the differences in plant characteristics, future research is encouraged to be conducted on the influence of plant characteristics for heat flux and the living wall thermal performance. The results of this study show potential trends in building energy performance with respect to the leaves density of the living walls. Therefore, the findings of this study provide

valuable insights for the planning and designing of living walls for a tropical climate. Due to the limitations of land in enhancing the natural green cover, green walls can be identified as one of the most feasible solutions to introduce green cover into urban areas, by integrating vegetation in to building envelope. Apart from the heat reductions, aesthetic benefits, air pollution reduction and habitat creation, green walls can provide substantial economic benefits in long term by reducing energy consumption for cooling buildings during the daytime. Integrating vertical greening in a building also contributes in receiving credit points under Sustainable Sites category, in GreenSL® Rating System of Sri Lanka Green Building Council (SLGBC) for green building certification.

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Biography:



Dr. Varuni Jayasooriya has completed her Ph.D. in the area of optimization of Green Infrastructure for industrial areas in 2017, from Victoria University Melbourne, Australia. She has made a strong and relevant contribution to the health and wellbeing of communities through the development of a systematic approach to Green Infrastructure, namely through her innovative simulation-optimization model, that allows users to identify optimum Green Infrastructure practices in the treatment of stormwater in urban areas. Currently, she works as a Senior Lecturer at Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka.
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GIS and RS Applications in Environmental Management

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Abstract

Geographical Information Systems (GIS) and Remote Sensing (RS) are used as tools for environmental management in different aspects. The study of 'GIS-AHP integrated approach for optimized landfill site selection for Matara District' mainly focused on sustainable utilization of land resource for a landfill site in Matara district, Sri Lanka. Eleven criteria were selected, constraint criteria were removed and factor criteria were used with Analytical Hierarchical Analysis (AHP) to find the weightages for factor criteria in weighted overlay analysis in GIS. Suitable places for landfill sites according to the criteria were used in this approach. In that way, GIS can be used as a tool to find out the most suitable area for different purposes in order to practice sustainable environmental management strategies more efficiently and effectively. The second application was on resources conservation of 'A potential habitat corridor for Western Purple-faced Langur between Forest Reserves in Sri Lanka: GIS in connectivity modelling'. The main focus of the second application was to connect fragmented forest patches due to anthropogenic activities using low-cost path analysis in GIS in order to provide the habitat for the IUCN listed purple color faced Langur. Final results show the best path to construct the rope bridge for the Langur. This methodology of GIS can be applied in many development projects while fragmenting different land uses and to provide uninterrupted habitat for the wildlife. Applications of GIS and RS can be used to manage natural resources in an efficient and effective manner.

Keywords: Landfill sites, Langur, low-cost path, site selection

Introduction

GIS is defined as set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes. RS is defined as the science and art of acquiring information (spectral, spatial and temporal) about material, objects, area or phenomena, without coming into physical contact with the material, objects, area or phenomena under investigation. GIS and RS together are used as effective and efficient tools for; sustainable environmental resources management, pollution detection and mitigation strategies, and disaster and natural hazards management. RS plays an important role as an effective data acquisition method for GIS data analysis. There are many data analysis methods available in GIS for different applications. In this paper, two data analysis methods were

applied namely, weighted overlay and least cost path analysis in two different environmental applications.

Materials and Methods

Application 1: GIS-AHP integrated approach for optimized landfill site selection for Matara District.

Landfill site selection in urban areas is a complicated process due to its huge impact on the people and the environment. Matara is a coastal district located in the South-west of Sri Lanka, and it has an area of 1282.5 km². As the site selection criteria for this study, surface water body, forest reserve, wetland, coastal zone, rainfall, town center, residential area, important buildings, transportation network, slope and soil were selected. Constrained criteria were developed using local government regulations, and suitable and non-suitable area maps was developed. Then suitable area map was used to find the low, medium and high suitable areas for a landfill site. In order to give relative weightages for each criterion, AHP was used in overlay analysis in GIS, and the landfill site selection map was developed for Matara District in Sri Lanka.

Application 2: A potential habitat corridor for Western Purple-faced Langur between forest reserves in Sri Lanka: GIS in connectivity modelling.

Deforestation has adversely affected its preferred habitat and sources of food. As the habitats overlapped, human – monkey conflict arose. LKFR (Labugama-Kalatuwawa Forest Reserve), IMFR (Indikada Mukalana Forest Reserve) and GFR (Gatemawara Forest Reserve) and Seetawaka wet zone botanic garden are scattered forest patches in the study area, thus, it is needed to get connected for Langur. Five main resistance criteria for Langur movement were selected, namely; land use, road density, canopy cover, human tolerance and Feeding Plant Species Richness and Density (FPSRD) (amount of human disturbance).

Land use layer: The land use is a significant factor in assessing the habitat suitability for any wildlife species. Land use layer of the area was obtained from the Survey Department, Sri Lanka, as digital data of a scale of 1:10,000. It was ground trothed and updated by digitizing. Land use layer classified into six major land uses, namely, forests, rubber plantations without home gardens, rubber plantations with home gardens, botanic gardens, home gardens and other cultivations. Scales were given from 1-6 for each land use.

Road density layer: Roads and traffic are another important factor, affecting wildlife populations since it can reduce or even eliminate populations of certain species from an area. Road layer of the area was obtained from the Survey Department, Sri Lanka, as digital data of a scale of 1:10,000 and was updated using a handheld GPS receiver.

Two basic types of roads were identified, namely, major roads (width ≥ 6 m) and minor roads ($3 \text{ m} \leq \text{width} < 6 \text{ m}$). The roads were weighted according to the width which is roughly proportional to the amount of disturbance or degree of difficulty an animal might have in attempting to cross the road. Road lengths were calculated using ‘calculate geometry’ functions, and road density per grid was calculated for each road type. Road density coefficient was calculated for each grid, following the equation given below, and road density layer was generated.

$$\text{Road density coefficient} \\ = 2 (\text{major roads density}) + (\text{minor roads density})$$

Canopy cover layer: Canopy cover is an essential requirement for Langur, since it is highly arboreal and confined to areas with high continuous canopy cover. The canopy layer was extracted from the Landsat satellite image using maximum likelihood algorithm of supervised image classification. It was clipped with the grid layer and canopy area for each grid was calculated via ‘calculate geometry’ functions. The data were then exported to Microsoft Excel to calculate canopy cover percentage (resistance value) per each grid.

Human tolerance layer: Many human-monkey conflict incidents are recorded in the area making assessing human tolerance an essential task in corridor designing. Consequently, high level of human disturbance makes a particular area less habitable for Langur. Human tolerances were assessed through a questionnaire survey conducted at household level following a systematic sampling strategy. Maximum of three households were interviewed from each sampling grid, based on the availability of houses. In evaluating the human tolerance towards monkey occurrence, human behavior upon monkey visitation to their home gardens was considered. Six ‘tolerance levels’ were identified ranging from a minimum tolerance of 1 to a maximum tolerance level of 6 and are comparable to the studies conducted under the Primate Conservation Project of SPEARS foundation, Sri Lanka.

Feeding Plant Species Richness and Density (FPSRD) layer: The diversity of feeding plants was assessed in terms of species richness. Species richness and density of feeding plants of Langur were calculated separately, relative to the area of each grid. The equation given below was developed to assess the langur’s Feeding Plant Species Richness and Density (FPSRD), in each grid. FPSRD was estimated by vegetation surveys following a stratified random sampling strategy with a 10% sampling size.

$$\text{FPSRD} = \text{feeding plant species richness} \times \text{feeding plant density}$$

Least-cost modelling for the suitable potential corridor route: The five resistance layers were converted into raster with 0.04 km^2 resolution. All the resistance values for each input criteria were brought to a common scale of 1-6

where '1' and '6' represent the least and highest resistance for langur movement respectively, by reclassifying. Thereafter, the five layers were combined to derive the overall resistance for Langur movement using weighted overlay. Weighting was based on educational judgments referring to previous literature; Land use layer, road density layer, canopy cover layer, FPSRD and human tolerance layer were given weightings of 15%, 15%, 40%, 15% and 15%, respectively.

Results and Discussion

Application 1: Landfill suitability area map for Matara District is shown in Figure 1.

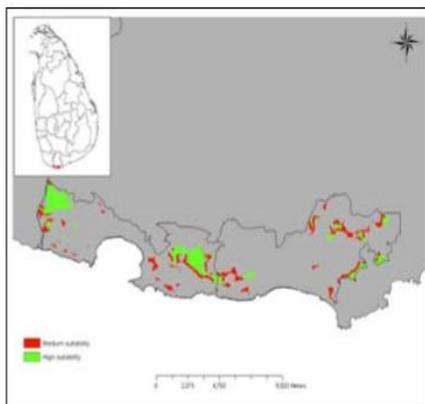


Figure 1: Landfill suitability map

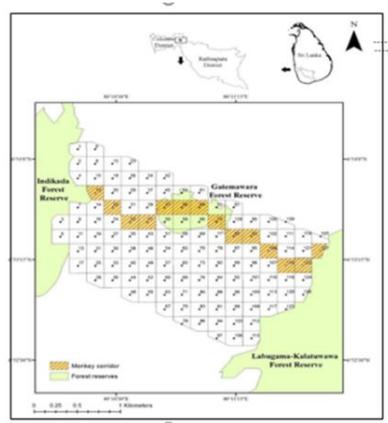


Figure 2: A potential habitat corridor

Figure 1 shows the higher suitability areas for landfill site in green color and medium suitability land areas in red color. When applying sustainable development strategies for selected criteria, it is very easy to allocate suitable places for any development project in the country. If the final map is not satisfied for user, selection criteria can be changed according to the local regulations, and methodology can be repeated. It will not consume much time. In this way, GIS and RS can be used very effectively and efficiently in land management.

Application 2: Figure 2 shows the potential habitat corridor for western purple-faced Langur.

According to the selection criteria, habitat corridor path is selected by GIS software. This path can be a rope bridge for monkeys. With this application also, it shows that GIS and RS can be used as an effective and efficient tool for conservation purposes.

Conclusion

RS is effective and efficient data source for GIS. Therefore, together GIS and RS can be used as effective and efficient tools for environmental management in any country in the world. Data currency in GIS matters for the accuracy of the final maps.

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Biography:



Dr. (Mrs.) V.P.A. Weerasinghe graduated in Agriculture from University of Peradeniya in 1996. She received DAAD scholarship in 2000 for her M.Sc. in Geoinformatics and Photogrammetry from Stuttgart University of Applied Sciences, Germany. She has completed her Ph.D. in Agricultural Engineering in 2007, University of Hohenheim, Germany. Her Ph.D. thesis was development of low cost NIR soil moisture sensor for gardening.

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The application of electrical impedance measurement on biomedical field

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Background

Oral cancer is one of the six most common cancers in the world, and tongue cancer is one of the most common intraoral malignancies. In the past ten years, the prevalence of oral cancer in Taiwan has increased by 160%, and the mortality rate increased by 110%.

Visual inspection is the first routine clinical practice to screen for oral cancer. However, oral cancer may not be noticed, which may delay diagnosis and adversely affect the patient's prognosis. Therefore, new oral cancer screening methods are needed.

Bioimpedance is a measurement of a biological impedance signal obtained by injecting a low-level sinusoidal current into the tissue and measuring the voltage drop generated by the tissue impedance. It has been introduced into clinical studies of breast cancer [1-4] and cervical cancer [5-7]. Therefore, this study aims to study the electrical characteristics of CTT and NTT in order to establish a reliable, low-cost, non-invasive and real-time new method for tongue cancer screening.

Methodology

Eight tongue cancer patients (7 men and 1 woman; T1 and T2 stages of oral squamous cell carcinoma) participated in this study and this study is ethically approved.

The impedance of tongue tissue was measured using a 4-silver-electrodes (1mm diameter each and 2mm between electrode centers) disposable probe (Figure 1) connected to an impedance analyzer. The experimental detail is summarized in Figure 2.

Results and Discussion

No statistically significant difference was found on patients' pre-and post-experimental oral temperature. Hence, the effect of temperature on patients' impedance is assumed to be negligible. Also, all measurements have good reliability and validity (Table 1).

The electrical properties of tongue tissues are summarized in Figure 4-5. Results showed that only the Re (p=0.005) parameter could significantly distinguish the CTT and surrounding NTT.

Conclusion

In conclusion, significant separation of CTT from surrounding NTT can be achieved using the measurement parameter of Re. Bioimpedance is a potentially promising technique for tongue cancer screening.

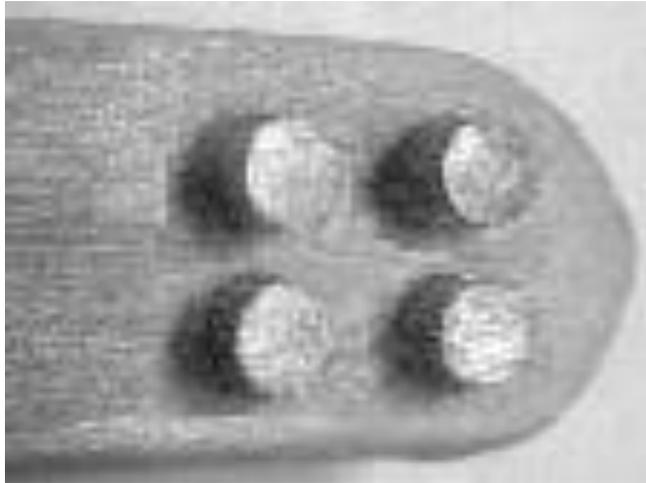


Figure 1. The disposable probe.

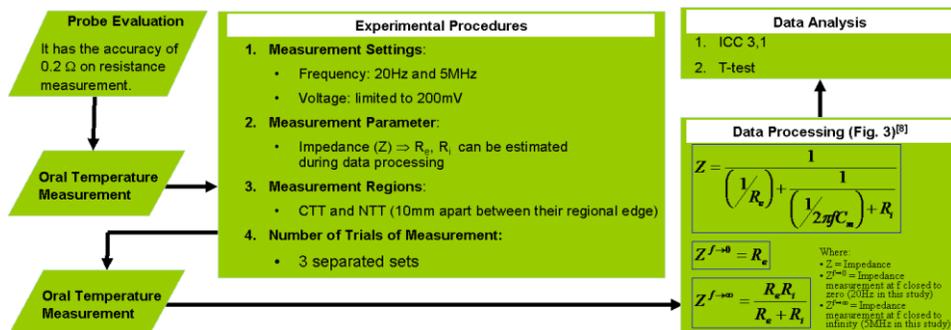


Figure 2. The flowchart of the experimental procedures, data processing and data analysis.

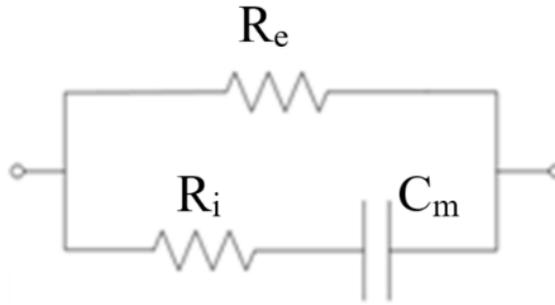


Figure 3. An equivalent circuit of tongue tissues. R_e and R_i are the resistance of the extra- and intra-cellular medium of the CTT and NTT respectively. C_m is the capacitance of the cell membrane.

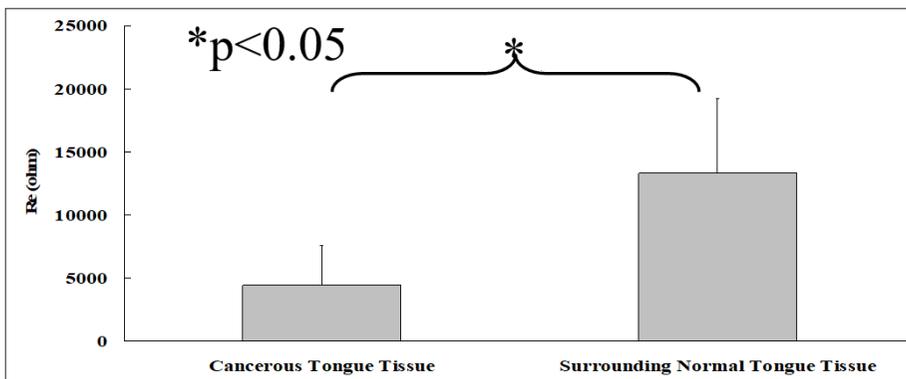


Figure 4. The R_e of CTT and surrounding NTT. Statistically significant difference was found.

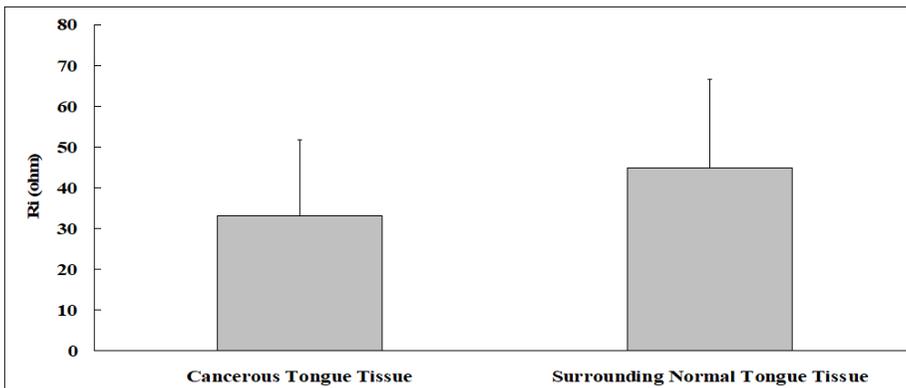


Figure 5. The R_i of CTT and surrounding NTT. No statistically significant difference ($p=0.213$) was found.

Table 1. Estimation of intrarater reliability (ICC 3,1) for the measurement of Re and Ri of CTT and surrounding NTT.

Intrarater Reliability (ICC 3,1)			
CTT		Surrounding NTT	
<i>R_e</i>	<i>R_i</i>	<i>R_e</i>	<i>R_i</i>
0.99	1.00	0.99	1.00

Keywords: Bioimpedance, tongue cancer, noninvasive

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Biography:



Prof. Congo Tak-Shing Ching obtained his BSc (Hons) in Prosthetics and Orthotics with first class honor from The Hong Kong Polytechnic University (PolyU) in 1999 and received his MPhil in Biomedical Engineering from PolyU in 2002. He went on to gain a PhD in Bioengineering from the University of Strathclyde, Glasgow, UK, in 2005. His main interests in research are in the area of biomedical instrumentation design, biosensors, tissue bioimpedance, biomedical electronics, biomedical optoelectronic, non-invasive medical diagnostics, and assistive technology. He is now serving as a Professor at the Graduate Institute of Biomedical Engineering, National Chung Hsing University, Taiwan.
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10 NCHU COLLEGES

College of Science (CS)

The College of Science consists of four Departments: Chemistry, Applied Mathematics, Physics and the Institute of Nanoscience. Its goal is to train students and researchers in monodisciplinary as well as multidisciplinary science with emphasis on nanotechnology, biophysics, organic and biological chemistry, and advanced mathematical techniques for computer applications.

College of Life Sciences (CLS)

This College aims at cultivating independent, well-rounded experts who investigate the inner workings of animals, plants, and microorganisms through innovative research methods. It covers the subject through the fields of biochemistry, cellular and molecular biology, population biology, and ecology. Faculty members of the College use interdisciplinary approaches to study gene structure, function, regulation, development, evolution, and interaction with the environment, and apply their findings to improve life on earth.

College of Engineering (CE)

With the goal of improving industrial development and human condition, CE focuses on the creation of new products or adding value to existing ones by working in the fields of opto-electronics, information technology, communications, polymer engineering, precision machinery, nano-technology, and special function materials. The CE faculty members also conduct research on hazard mitigation, vibration control, and environment conservation in order to reduce damage and increase durability.

College of Agriculture and Natural Resources (CANR)

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College of Liberal Art (CLA)

CLA aims at cultivating students who are well versed both in Chinese and Western scholarly traditions. In addition to the main curricula, CLA also offers specialized programs and courses which support students in developing diverse skills. The Humanities Digital Archives and the Value-Added Application Program provide the students with the ability to collect digital archival information. The Deer Cultural Heritage Center offers training courses and internship opportunities to develop students' skills in news coverage and editing, as well as media and image production and broadcasting. The Language Center offers a Chinese course package intended for foreigners and international students.

College of Veterinary Medicine (CVM)

The of the College of Veterinary Medicine's mission is to advance animal and human health through education, research, and service via functional integration of veterinary science, which is taught in the Department of Veterinary Medicine, the Graduate Institute of Microbiology and Public Health, and the Graduate Institute of Veterinary Pathobiology, as well as clinical medicine conducted in the Veterinary Medical Teaching Hospital and Animal Disease Diagnostic Center. The research of the two graduate institutes mainly focuses on the diagnosis and prevention of epidemic diseases of humans and animals by modern technologies.

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Beyond Islands: Academic Networking between Taiwan and Sri Lanka
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