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List of RGJ advisors 2023/2024

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Keywords: Reduced Graphene Oxide; Nanocomposites; Metal oxide nanoparticles; Dyes; Photodegradation.

Summary of research:

An optimized process for synthesizing a new Mg and Au decorated rGO nanocomposites using hydrothermal method will be developed. Optimization of the synthesis process can yield tailor-made nanoparticles in which photocatalytic efficacy plays a major role through specific morphological and physicochemical process development. The transition metal embedded in rGO structure can absorb more hazardous dyes and help to remove them effectively. A synergistic study between various transition metals and rGO will promote more dye degradation. This research provides new scientific information, evidence and innovation leading to international scientific papers and patents that are very useful for the environmental remediation.

การกรอกรายละเอียดในแบบฟอร์มนี้ ต้องดำเนินการให้ครบถ้วนตามความเป็นจริง หากตรวจสอบพบว่ามีการปกปิดหรือเป็นเท็จ วช. ขอสงวนสิทธิ์ที่จะไม่พิจารณาสนับสนุนและจะเป็นผู้ไม่มีสิทธิ์รับทุน วช. เป็นเวลา 3 ปี

แบบเสนอโครงการวิจัย (Research Project)
ประกอบการเสนอขอทุนอุดหนุนการวิจัยของสำนักงานการวิจัยแห่งชาติ (วช.)
โครงการปริญญาเอกกาญจนาภิเษก (คปก.) ภายใต้ความร่วมมือไตรภาคีไทย-สวีเดน
ประจำปีงบประมาณ 2567

1. ชื่อโครงการวิจัย

Transition metal decorated reduced graphene oxide nanocomposites for photocatalytic dye degradation

2. ชื่อ-สกุล อาจารย์ที่ปรึกษา

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3. กลุ่มสาขาวิทยาศาสตร์พื้นฐานที่สมัคร (เลือกเพียง ๑ กลุ่ม)

☐ ชีววิทยา (Biology) ☐ เคมี (Chemistry)
☑ ฟิสิกส์ (Physics) ☐ คณิตศาสตร์ (Mathematics)

4. ผู้ใช้ประโยชน์ (Research stakeholders) (กรณีมีความร่วมมือฯ) เช่น ความร่วมมือของหน่วยงานภาครัฐ (เช่น กระทรวง กรม)/เอกชนที่ร่วมสนับสนุนทุนวิจัย เช่น MOU เป็นต้น

☐ มี...(*โปรดระบุชื่อความร่วมมือ และหน่วยงาน*)...
☑ ไม่มี

5. คำสำคัญ (Keyword) ของโครงการ

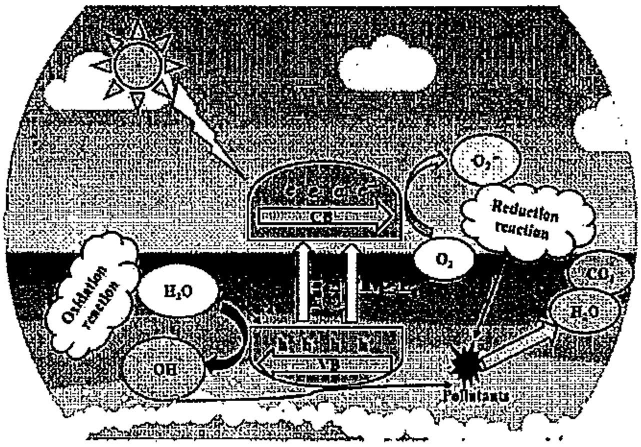
Reduced Graphene Oxide; Nanocomposites; Metal oxide nanoparticles; Dyes; Photodegradation.

6. ความสำคัญและที่มาของปัญหาที่ทำการวิจัย (Problem statement and significance of research)

Individually, graphene oxide (GO) and reduced graphene oxide (rGO) have shown promising results in photocatalytic dye degradation: for example, the photodegradation of Congo red, rhodamine B, methylene blue, and resazurin. However, studies have shown that GO and rGO in its pristine form is not photoactive enough to photodegrade metal oxide (MO) and orange II dyes. This is because of the rapid recombination of photogenerated charge carriers. To date, few efforts have been made for improving the photocatalytic performance of rGO. Doping transition metal nanoparticles is one way to modify the charge transfer characteristics of rGO. Doping transition metal co-catalyst could promote the photocatalytic reaction and serves as reaction sites, increase the charge separation and transport driven by interface formed between metal co-catalyst and light-harvesting semiconductor (rGO).

7. ทฤษฎี/สมมุติฐานของโครงการ (Hypothesis)

Photocatalysis is a composite word composed of two parts, "photo (light)" and "catalysis". Photocatalysis is a chemical reaction accelerated by light and a substance/semiconductor interaction. When the light of a suitable wavelength is irradiated over a semiconductor, it induces photo-excitation by consuming photon energy. As a result, the electrons from the catalyst valence band (VB) get excited to the conduction (CB) by leaving holes in the VB. The energy gap between the VB and CB is known as the "band gap". It corresponds to the wavelength of the light by which the photocatalyst can effectively absorb it. After photo-excitation, the excited charge carriers would separate and transfer onto the photocatalyst's surface and undergoes subsequent oxidation and reduction reactions with reactant species.



Schematic representation of the mechanism of photocatalytic degradation of pollutants.

8. วัตถุประสงค์ของโครงการ (Objectives)

1) Synthesis of reduced graphene oxide (rGO) sheet.
2) Synthesis of metal (magnesium, gold) decorated rGO nanocomposites
3) Characterization using SEM, HRTEM, EDX, XRD, UV-visible, FTIR, Raman analysis and Brunauer-Emmett-Teller (BET) measurements.
4) Photocatalytic dye degradation against methyl red and Rhodamine B dyes.

9. การทบทวนวรรณกรรม/ผลงานวิจัยที่เกี่ยวข้อง (Literature Review)

The alarming rate of water pollution associated with urbanization and industrialization is one of the grimmest issues for natural resources. Water contamination is caused by many factors, including industrial wastes such as fertilizers, hydrocarbons, pesticides (phenols and biphenyls), plasticizers, detergents, oils, pharmaceuticals, proteins, carbohydrates, toxic organic dyes, and several other organic pollutants [1–6]. To remove organic pollutants, various strategies have been implemented such as adsorption [7-8], filtration [9], photocatalytic degradation [10-11], and catalytic reduction [12]. Among these approaches, photocatalytic degradation has received tremendous attention from researchers due to its efficacy and cheap and effective process is widely used to purify water and decompose organic pollutants into nontoxic substances [13–16]. Recently, carbon-based materials have attracted increased attention for photocatalytic applications due to their unique chemical and physical properties. GO is one of the emerging carbonaceous photocatalysts. It can be readily dispersible in water due to its structure, which consists of the sp^3 domain with hydrophilic oxygenated functionalities and the hydrophobic π-conjugated aromatic sp^2 domain. Generally, monolayer graphene sheets are inapt for the photocatalytic process because of their hydrophobic Sp^2 domain. However, by introducing oxygen functionality, one can develop a sp^3 domain on the graphene structure. Therefore, the valence band origin gradually shifts from π-orbital of graphene to oxygen 2p-orbital, whereas the conduction band edge remains as π^*-orbital. These fascinating properties enable GO to be a more practicable photocatalyst, and to host a great number of active sites to interact with reactive species [17].

Thus fabrication of novel nanostructured photocatalysts based on reduced graphene oxide doped with transition metal elements (Mg, Au) by using the chemical precipitation method can be very significant. The microscopy analysis by TEM, elemental analysis by EDX, Raman spectra, BET analysis, UV-visible and other analysis will help to evaluate the physico-chemical properties of the nanocomposites. Likewise, the photocatalytic studies will reveal whether the doped reduced graphene oxide samples can exhibit enhanced dye degradation efficiency compared to the undoped reduced graphene oxide sample.

10. ระเบียบวิธีวิจัย (Methodology)

10.1 Synthesis of metal-doped GO nanocomposites:

Synthesis of MgO-x%rGO, Au-x%rGO nanocomposites was prepared by solvol thermal method with modification. Briefly, 4 g GO was dissolved in a solution of 60 ml ethanol mixture using by ultrasonic treatment for 6 h. 400 mg AR grade magnesium chloride, Gold(III) chloride was added to a GO solution with difference mass ratios of rGO (0, 5, 10, 15, 20 and 25 wt% respectively). To obtain a homogeneous suspension, the mixtures were stirred continuous stirring for 1 h. Afterwards the suspensions were transferred to a Teflon-lined autoclave which was maintained at 180 °C for 8 h. During this step, the GO will be reduced to rGO. The suspended products were removed by filtration. They were then rinse in by DI water several times and dried at 60 °C for 12 h. The sample produced by this way will be denoted as MgO -x%rGO and Au-x%rGO with x=0, 5, 10, 15, 20, 25

10.2 Characterization:

The synthesized nanocomposites will be characterized using by Scanning Electron Microscope (SEM), X-ray diffraction spectroscopy (XRD), UV-visible spectroscopy, high-resolution transmission electron microscopy (HRTEM), energy dispersive spectroscopy (EDS), and Fourier transform infrared spectroscopy (FTIR). Further, Raman analysis and Brunauer-Emmett-Teller (BET) measurements will also be carried out.

10.3 Photocatalytic test:

The photocatalytic activity of the samples will be evaluated from the decomposition of methyl red and Rhodamine B dyes under UV irradiation. For the photocatalytic test, 10 mg photocatalyst will be dispersed in 50 ml of 40 ppm dye solution. The catalytic solution will be sonicated for 2 h in the dark to achieve the adsorption-desorption equilibrium. After reaching the adsorption-desorption equilibrium, the catalytic solution will be irradiated with a mercury lamp (150 W) in a custom-made photoreactor for 120 min. The photodegradation of metal oxide will be estimated by monitoring the absorption maximum at 460 nm. The photocatalytic dye degradation efficiency will be calculated from the following equation:

$$\% \text{ Degradation} = \{[A(0) - A(t)]/A(0)\} \times 100\%.$$

Where A (0) is the initial absorbance before light treatment, and A(t) is final absorbance of dye after light treatment. The heterogeneous photocatalytic reaction between rGO-based nanocomposites and water-soluble methyl red and Rhodamine B dyes can be expressed via pseudo-first-order kinetics.

11. ขอบเขตของการวิจัย (Scope of the study)

The study has a wide scope in developing novel nanomaterials with dye degrading capabilities that can help to mitigate the environmental pollution.

12. ผลผลิต (Output) ผลลัพธ์ (Outcome) และ ผลกระทบ (Impact) ที่คาดว่าจะได้จากการวิจัย

Output

- One Ph.D. student
- Two publications

Outcome

- The publications has been cited

Impact

- Collaboration between Thailand and Sweden
- Exchange student between Thailand and Sweden