ACHIEVING SUSTAINABLE WATER PURIFICATION: TAILORED GRAPHITIC CARBON NITRIDE FOR THE REMOVAL OF ORGANIC PERSISTENT CONTAMINANTS

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Background
- Great challenges from environmental pollution;
- Many organic pollutants are recalcitrant in conventional wastewater and water treatment process;
- Pollutants include pharmaceuticals and personal care products, pesticides, and endocrine disrupting compounds.

Methods
- Synthesize g-C₃N₄ samples
  - Bulk g-C₃N₄
  - Mesoporous carbon doped g-C₃N₄
- Photocatalytic degradation tests (Figure 3)
  - Phenol was selected as a probe contaminant;
  - The optimal supramolecular g-C₃N₄ was applied for the degradation of persistent organic micropollutants (i.e., atrazine, carbamazepine, and sulfamethoxazole);
  - Their longevity in matrices representative of water treatment was evaluated;
  - The reactivity was evaluated under both simulated solar irradiation (visible light) and LED irradiation;
- Contaminant was analyzed by high performance liquid chromatography (HPLC).

Results
- Bulk g-C₃N₄ from different precursors
  - Urea-based g-C₃N₄ shows the highest photocatalytic activity in phenol degradation pseudo-first-order rate constant of 0.026 min⁻¹, and its rate constant is 6.7 folds higher than those of g-C₃N₄ synthesized from the other precursors.
  - This is likely due to a larger surface area and self-carbon-doping (i.e., increased C/N) resulted increased visible light adsorption.
- Carbon doped g-C₃N₄
  - The color of carbon doped g-C₃N₄ becomes darker with increased carbon content (Figure 4);
- More Carbon

Challenges
- Photocatalysis:
  - An promising green technology to utilize renewable solar energy for water purification;
  - Numerous photocatalysts explored in the past decades are suffered from limited visible light adsorption, low reactivity, instability, and high cost.

Objectives
- We aim to explore the potential applications of g-C₃N₄:
  - A novel polymeric photocatalyst;
  - Visible light responsive (460-650 nm);
  - Physically and chemically stable;
  - Low cost for production;
  - Limited research on persistent organic pollutants removal.
- Photocatalytic degradation kinetics of phenol on carbon doped g-C₃N₄ (Figure 5).
- More Carbon

Results
- MC and MCB have mesoporous structures and higher reactivity for g-C₃N₄ (Figure 5 Left).
- The reduction of PL intensity and red-shifted peak both indicate that the addition of CA and BA may lower the charge recombination compared to M only derived from melamine (Figure 5 Right).
- MC and MCB still perform the degradation of other persistent organic micropollutants under visible light irradiation.

Conclusion
- MCB, the optimal g-C₃N₄ synthesized via supramolecular method has the highest reactivity for organic persistent micropollutants degradation under visible light (>400 nm), which was contributed to the increased surface area and improvement of charge separation when compared with M.
- g-C₃N₄ holds promise for contaminant degradation in water treatment or advanced wastewater treatment practices.
- The energy-efficient LEDs are a promising alternative light source for the photocatalytic degradation of persistent contaminants when sunlight is not available.

Future Work
- The “Rainbow” Photocatalyst
- The Photocatalytic Membrane Reactor
- We thank GW startup fund for supporting the research.

Acknowledgement

Results
- Little to no inhibition on atrazine degradation kinetics was observed in simulated complex water (Figure 8 left) as well as water samples collected from different stages in water and wastewater treatment process (Figure 8 right).
- A comparable photocatalytic activity was achieved under monochromatic white LED and Xenon lamp irradiation (>400 nm) (0.55 vs. 1.76 m² (mole of photon)⁻¹).
- The reactivity under LED irradiation at a shorter wavelength is higher than that under Xenon lamp irradiation.
- The “Rainbow” Photocatalyst
- The Photocatalytic Membrane Reactor
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