Odyssey Research Programme
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Incorporating Chaotropicity onto Photothermal Material to Chemically boost Solar Steam Generation

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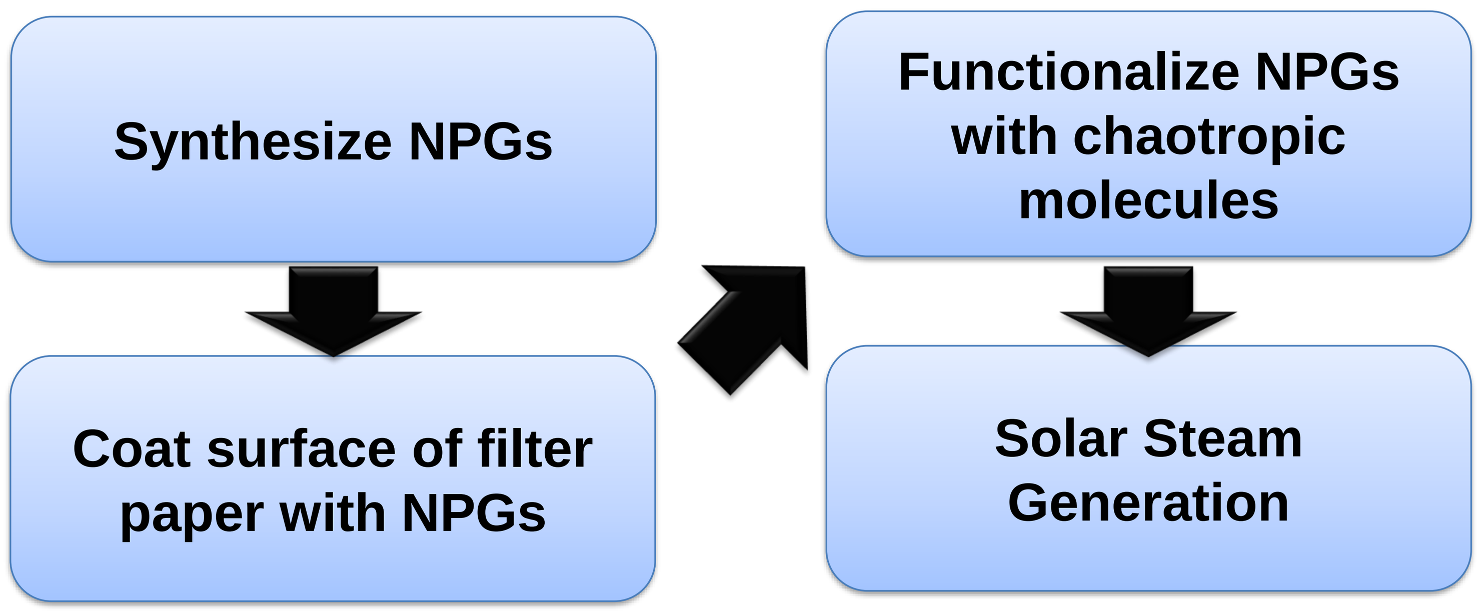
Introduction

Solar steam generation is a sustainable and environmental-friendly method for clean water production via distillation. However, conventional photothermal materials have low photothermal evaporation efficiency. Most research focused on tailoring these photothermal materials which could already be reaching their limits. In this study, we are focusing on a new strategy to chemically incorporate chaotropicity onto nanoporous gold particles (NPGs) to disrupt the hydrogen network of water molecules, thereby promoting subsequent heat-to-steam generation. Our key findings are supported by density functional theory (DFT) simulations to compute the hydration pattern of water molecule around the different functional groups. This chemical approach can be expanded to other photothermal materials to further push their intrinsic limits.

Methodology



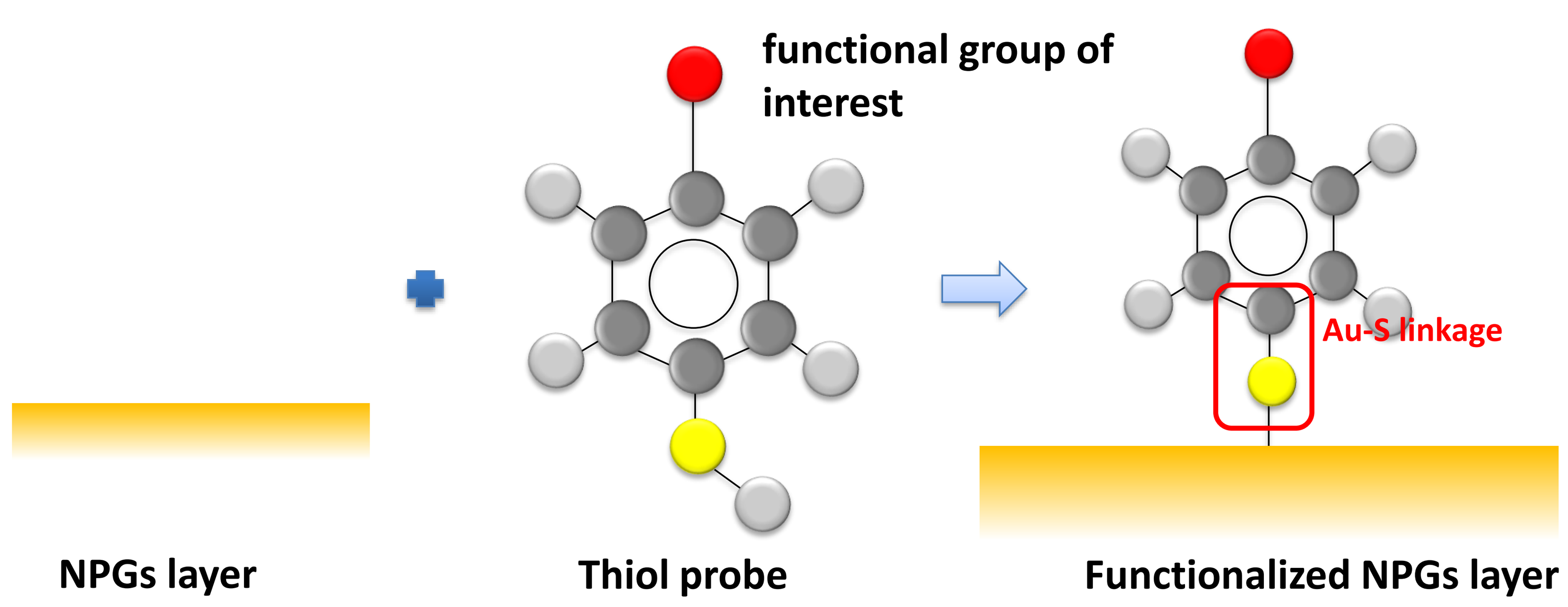
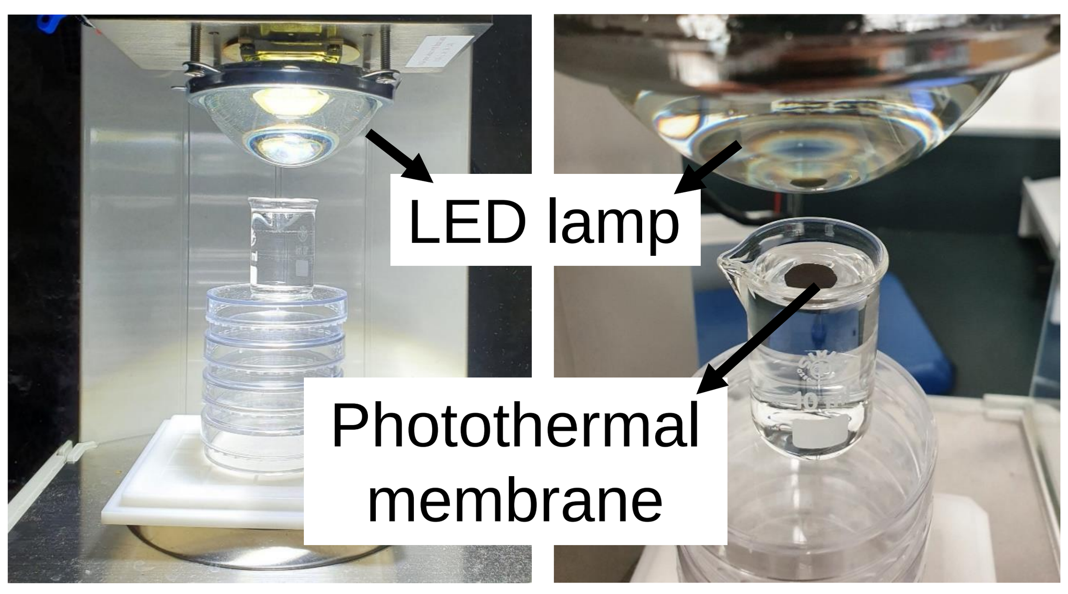


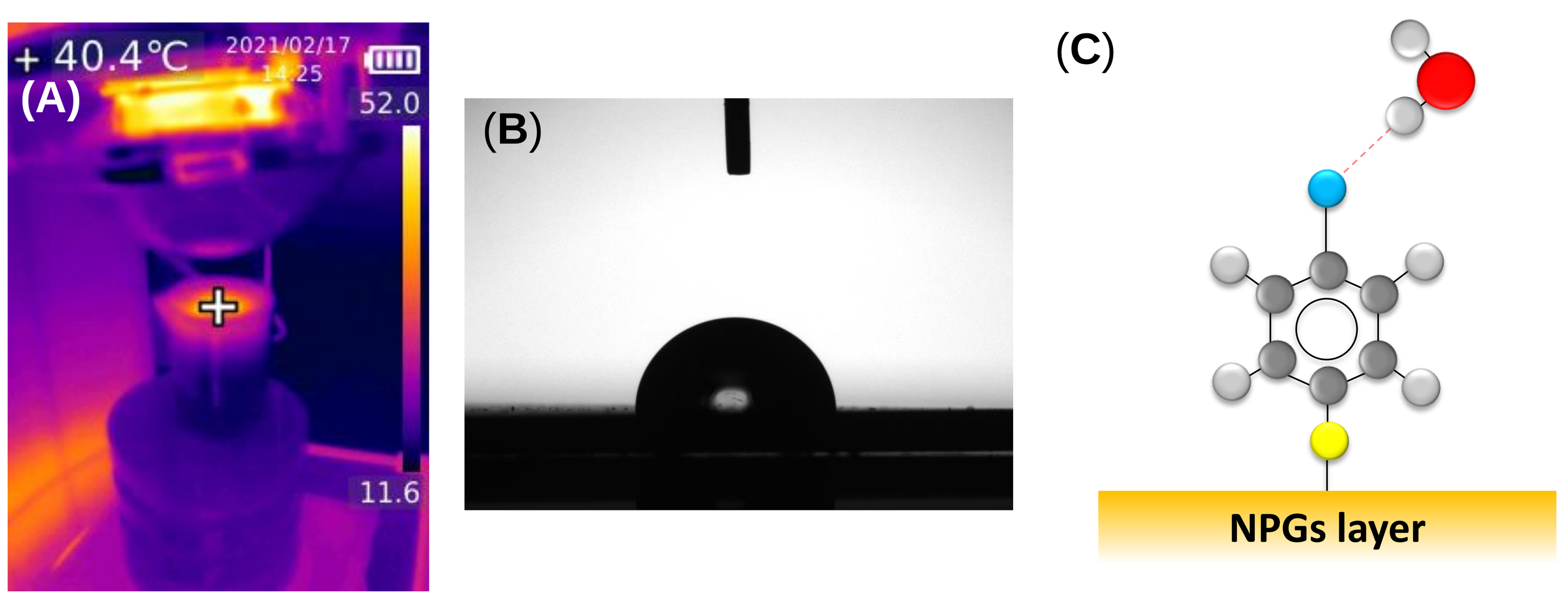
Figure 1. shows the functionalization process of NPGs via Au-Sulphur linkage.

Data collection



- Surface of filter paper is coated with constant mass of NPGs for different functional groups.
- Distance between the light source and the water level is fixed.

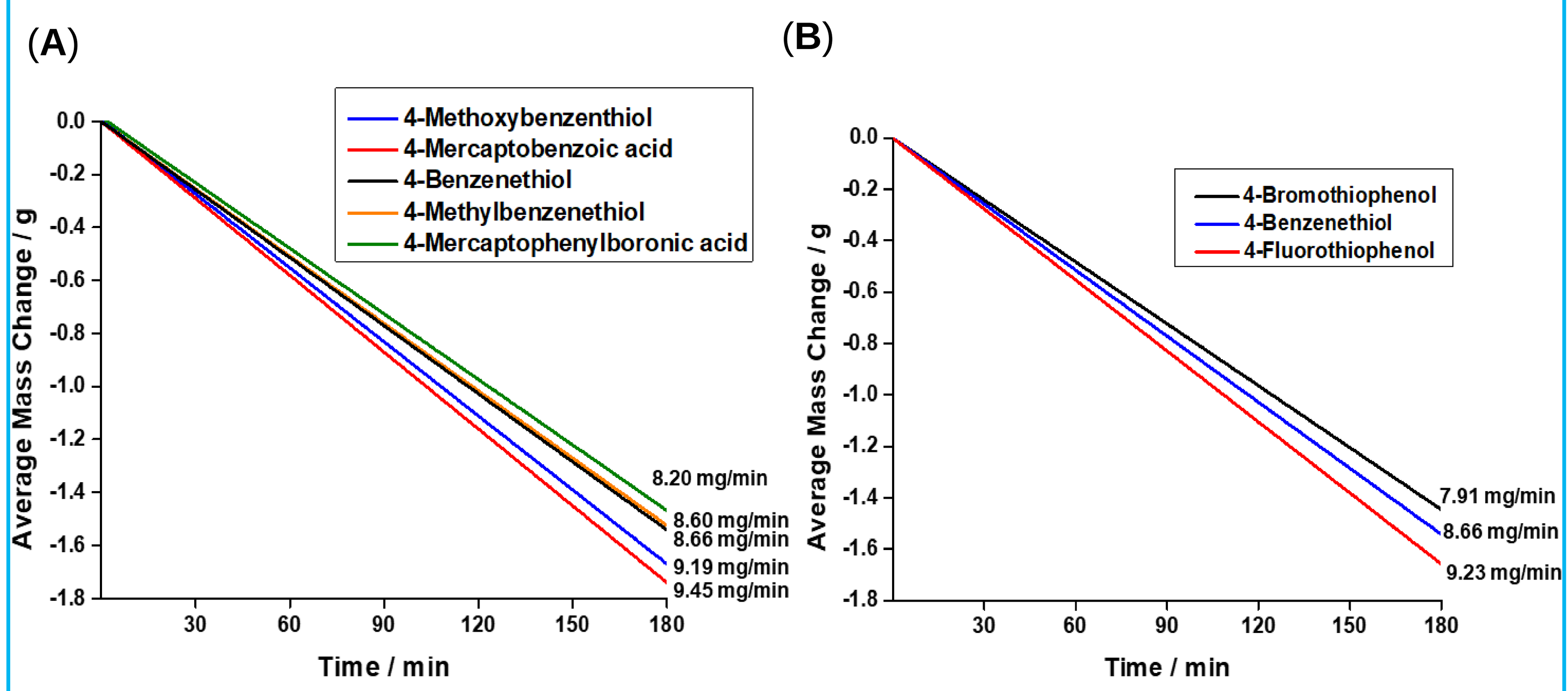
Figure 2. shows the general experimental setup for the solar steam generation.



(**A**) shows the IR image of photothermal temperature during the interfacial evaporation to check reproducibility. (**B**) shows the contact angle of functionalized gold film coated on Si substrate. (**C**) shows the DFT simulation on the hydration pattern of water molecule near to a particular functional group.

Result and Discussion

- The different functional groups functionalized were divided into two series based on their similarity in contact angle measurements to ensure differences in evaporation rate are not due to solid-liquid contact.
- Photothermal temperature of the interfacial evaporation is constant at ~45 °C.



(**A**) shows the photothermal evaporation rate for different functional groups with contact angle measurements ~55°. (**B**) shows the photothermal evaporation rate for different functional groups with contact angle measurements ~80°.

Conclusion

The solar steam generation performance is enhanced due to the surface chemistry of functionalized NPG. The experimental data obtained are compatible with the DFT simulated molecular models. We have developed a unique plasmonic-based photothermal membrane which boosts the rate of solar steam generation. By incorporating chaotropicity onto NPGs, it was found that the photothermal evaporation rate increased by 27% as compared to non-chaotropic incorporated NPGs membrane, despite having approximately constant contact angle and interfacial heating temperature.

Future Work

Investigate the effect of interaction energy between water molecule and a particular functional group on the photothermal evaporation rate.

References

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