VIDEO ARTICLE

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Designing Nanohybrids for Energy, Environmental and Biomedical Applications

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Graphical Abstract

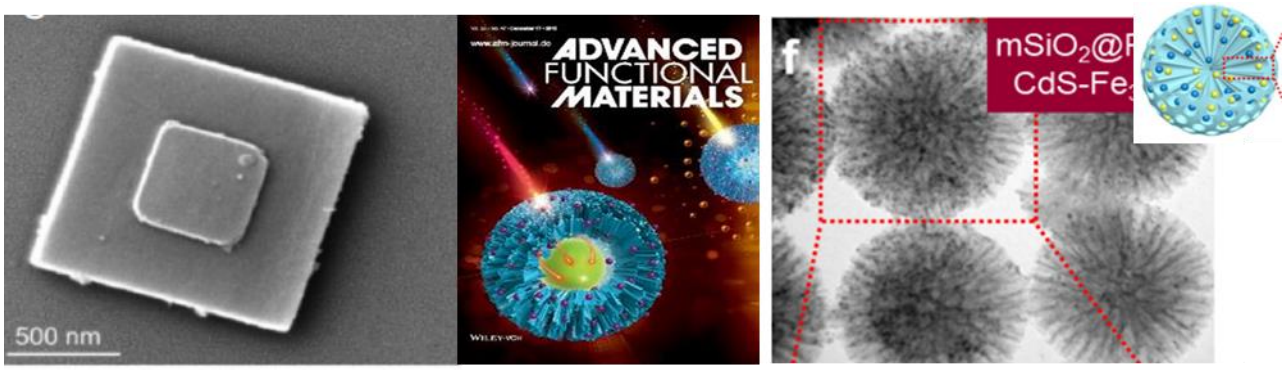

Fig. 1. Two-dimensional, homojunctioned nanostacks of metal organic framework for solar fuel production (left), plasmonic nanoparticle enhanced core-shell broadband photocatalyst for pollutant degradation (middle) and multifunctional porous SiO_2 nanoparticles loaded with superparamagnetic nanoparticles and photoluminescent quantum dots for biomedical applications (right).

Abstract

With unique physical and chemical properties and high potential for many important applications, nanomaterials have attracted extensive attention in the past two decades. Further combining different nanomaterials into nanohybrids can potentially lead to improved properties/performance or even better, multiple functions. In this talk, I will present some of our recent work on the rational design and realization of nanohybrid materials as well as their applications in solar fuel, photocatalysis and biomedicine [**1-5**]. It is known that forming nanomaterials junctions represents an important, promising strategy for realizing broadband photocalysis in strategically important applications such as solar fuels and photocatalytic degradation of pollutants in our environments. In one of our works, we stacked 2-dimensional (2D) black phosphorous (BP) nanosheet and graphitic carbon nitride (g-C3N4) nanosheets, which led to a 2D-on-2D heterojunction photocatalyst and demonstrated much enhanced activity (H2 production rate) both under $\lambda > 420$ nm and $\lambda > 475$ nm light irradiation, as compared to BP and g-C3N4 nanosheets alone, and long-term stability as well. Another example is about the construction of homojunctions of nanoplates made of metal-organic frameworks (MOF). The well-defined MOF homojunction was prepared by a facile one-pot synthesis route directed by hollow transition metal nanoparticles. The homojunction is enabled by two concentric stacked nanoplates with slightly different crystal phases. The enhanced charge separation in the homojunction was visualized by in-situ surface photovoltage microscopy. The as-prepared nanostacks displayed a

visible-light-driven carbon dioxide reduction with very high carbon monooxide selectivity, and excellent stability. If time allows, I will also show how we prepared multifunctional nanoplatforms composed of multiple superparamagnetic nanoparticles and near infrared quantum dots in single particles and how they are useful in serving as bimodal imaging probes and bimodal hyperthermia agents. All the work highlights the benefits of the nanohybrids, where rational design is the key in order to maximize these benefits.

Keywords: Nanohybrids; clean energy; solar fuel; nanobio; photocatalytic pollutant degradation.

Acknowledgements

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Biography

Dongling Ma, holder of the Canada Research Chair (Tier 1) in Advanced Functional Nanocomposites, has been a professor at Institut national de la recherche scientifique (INRS), Canada since 2006. Her main research interest consists in the development of various nanomaterials (e.g., semiconductor quantum dots, transition metal catalytic nanoparticles, plasmonic nanostructures) and different types of nanohybrids for applications in energy, environment, catalysis and biomedical sectors. She has co-authored >160 journal articles in a broad range of areas, centered on materials science, in selective, high-impact journals such as *J. Am. Chem. Soc*, *Nat. Commun.*, *Adv. Mater.*, *Adv. Energy Mater.*, *ACS Nano*, *Adv. Funct. Mater.*, *Energy Environ. Sci.*, *Chem. Mater*. and *Chem. Soc. Rev*. She has co-authored 6 patents (4 granted and 2 under review) and 4 book chapters. She has delivered >120 invited speeches at international conferences and prestigious universities/government laboratories. She serves on multiple journal editorial advisory boards, including the prestigious *ACS Energy Lett.*, *ACS Applied Nano Materials*, *Scientific Reports* (Springer-Nature), *Frontiers (Energy)*, *PhotonX* (Springer), etc. She also acts as the section Editor-in-Chief for the section "Solar Energy and Solar

Cells" of *Nanomaterials*, and Section Editor of *National Science Review* (NSR, Materials Science). Her recent awards include the 2022 Clara Benson Award from the Chemical Institute of Canada.

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