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Enhancement of Broadband Solar Light Absorption and Photocurrent Increase of C_3N_4 Nanoparticles Combined with TiN and Carbon Nanoparticles

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The use of solar energy to produce hydrogen fuel from overall water splitting is a promising means of renewable energy storage. In the past years, various inorganic and organic materials have been developed as photocatalysts for water splitting driven by visible solar light.[1] Plasmonic metal nanostructures has been proposed to offer a route to improve the solar energy conversion efficiency of inorganic/semiconductors materials system.[1,2] C_3N_4 is an Earth-abundant and low-cost semiconducting photocatalyst material capable of generating H_2 and H_2O_2 from water.[3] The band gap energy of 2.7 eV and high valence band and conduction band positions [1.8 and –0.9 eV versus reversible hydrogen electrode (RHE)] makes it promising material for visible light photocatalysis. During water splitting, C_3N_4 require sacrificial reagent and also suffers from poisoning by the produced H_2O_2, which is difficult to remove from the C_3N_4 surface.[4] Various attempt have been made to improve the catalytic activity of C_3N_4.[3,4]

Here, we show the strategy to increase the solar light absorption by making a composite of C_3N_4 nanoparticles and plasmonic TiN nanoparticles to improve the photo-electrochemical water splitting performance under simulated solar radiation. Utilization of the broadband plasmonic resonance of the TiN particles and the incorporation of carbon dots (C-Dots) into the C_3N_4 matrix (Fig. 1a) leads to an increase in the UV-vis to NIR absorption over the entire solar spectrum range. The simple chemical synthesis route is used to grow TiN nanoparticles on C_3N_4-carbon dots composite. The hot electron injection from plasmonic nanostructure to composite and C_3N_4 plays role in photocatalysis (Fig. 1b), whereas C-dots acts as chemical catalyst for the decomposition of H_2O_2 into O_2. C-dots plays major role in avoiding the sacrificial reagent and catalytic poisoning. This two-step approach overcomes the low optical absorption, spectral utilization and charge recombination losses, and gives effective way to improve the photocatalytic activity. By incorporating TiN the catalytic performance of C_3N_4-C-dots is increased by 6-fold.

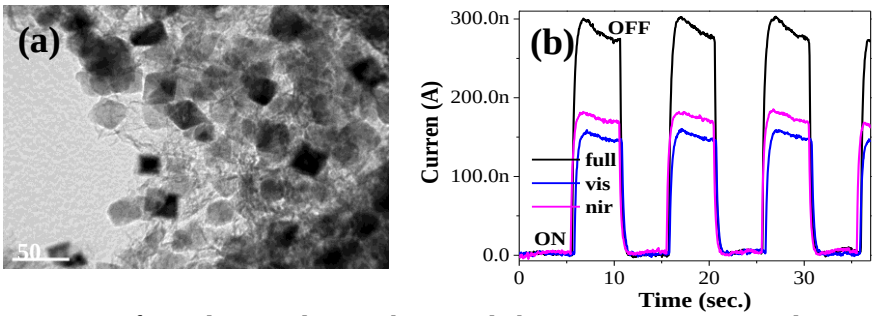

Figure 1. TEM image of TiN decorated C_3N_4 sheets and photocurrent response under simulated visible light.

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