# Effect of HNT surface modification on photocatalytic hydrogen production of HNT/g-$C_3N_4$

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Photocatalytic water splitting is a promising method enabling environmentally friendly hydrogen production. In recent years, a large number of materials such as $TiO_2$ [1], ZnO [2], CdS [3], g-$C_3N_4$ [4], and $Fe_2O_3$ [5] have been studied to develop an efficient photocatalyst for photocatalytic water splitting. Among them, metal-free g-$C_3N_4$ takes considerable attention due to its chemical stability, suitable band gap (2.7 eV) allowing absorption of visible light, tunable electronic properties, and low cost [6]. However, it suffers from photoinduced charge recombination, which leads to inefficient water splitting and hence hydrogen production [7]. There are, therefore some strategies such as doping and the formation of heterojunction to overcome charge recombination issues [8]. Another critical problem is the strong agglomeration of g-$C_3N_4$ catalysts causing a reduction in the effective surface area and hence photocatalytic activity. This is typically due to the utilization of high-temperature synthesis routes [6]. Employment of substrate material and synthesizing g-$C_3N_4$ on the substrate is one of the effective approaches to prevent agglomeration of g-$C_3N_4$ [9].

In the current work, halloysite nanotubes (HNT) were employed as a substrate material in order to reduce the g-$C_3N_4$ agglomeration and extend the effective surface area of g-$C_3N_4$, which leads to strengthening of the pathways of charge transfer and prolonging the lifetimes of photoexcited carriers. In the study, the HNT surface was also chemically modified using both acidic ($H_2SO_4$) and alkali (NaOH) solutions to create defects on the HNT surface and unzip the HNT spiral structure [10]. This approach also results in the formation of hydroxyl groups on the surface of HNTs, allowing for better dispersion of the HNT in water, and hence better dispersion of g-$C_3N_4$ photocatalysts.

g-$C_3N_4$ synthesized on the HNTs were chemically and structurally characterized. Following the material characterizations, g-$C_3N_4$/HNT photocatalysts were subjected to photocatalytic water splitting tests to identify the effect of HNT surface modification on the photocatalytic activity of g-$C_3N_4$ photocatalysts. Water splitting tests were performed under UV (250-385 nm) and visible (385-740 nm) lights generated by the Asahi Spectra MAX-350 300W Xenon light source. The gases produced as a result of photocatalytic water splitting were analyzed and monitored by an online gas analyzer (Hiden Analytical QGA).

**Acknowledgment**
Authors gratefully acknowledge the financial support from the Scientific and Technological Research Council of Turkey Technology and Innovation Support Programs Directorate under the 1507 - TUBITAK SME R&D Start-up Support Program and project number 7240243.

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