

## Efficient approach for simultaneous CO and H<sub>2</sub> production via photoreduction of CO<sub>2</sub> with water over copper nanoparticles loaded TiO<sub>2</sub>

Nikita Singhal<sup>1,2</sup>, and Umesh Kumar<sup>1,2</sup>

<sup>1</sup> Chemical Science Division, CSIR-Indian Institute of Petroleum, Dehradun-248005, India

<sup>2</sup> AcSIR-Academy of Scientific & Innovative Research New Delhi, India

*E-mail: singhalnikita17@gmail.com*

**Introduction:** The CO<sub>2</sub> transformation into fuel by using solar light irradiation is an effective method as no extra energy required with no negative influence on the environment. Different types of photocatalysts have been already introduced by many researchers for CO<sub>2</sub> reduction.<sup>[1]</sup> Among all reported material TiO<sub>2</sub> is considered as a promising catalyst due to its high abundance, high stability and low cost.<sup>[2]</sup> However fast recombination, and UV irradiation requirement limits its efficiency. Different strategies were addressed to improve photocatalytic activity of TiO<sub>2</sub>.<sup>[3]</sup> Due to the low cost and availability, copper would be a better choice to modify TiO<sub>2</sub>.

Herein, we describe the successful synthesis of copper/TiO<sub>2</sub> nanoparticles in which ex-situ synthesized Cu NPs were dispersed on the surface of TiO<sub>2</sub>. And the synthesized copper/TiO<sub>2</sub> nanoparticles were well characterized and capitalized for the CO<sub>2</sub> photo reduction with water vapour to yield CO as major product under UV radiation.

**Synthesis:** Cu Nps were prepared by chemical reduction route and loaded over lab synthesized TiO<sub>2</sub> nanoparticles followed by calcination or hydrogenation to obtain a series of Cu/TiO<sub>2</sub>. Different characterization were followed (XRD, UV, and TEM) to study physiochemical properties.

**Result and Discussion:** XRD pattern reveals [that prepared catalysts contain only anatase phase of TiO<sub>2</sub>. (JCPDS 21-1272) A small peak present at ca. 43.5° corresponding to (111) hkl plane of copper metal in 2% Cu-Red/TiO<sub>2</sub>. (JCPDS 85-1326) While the UV spectra shows that prepared TiO<sub>2</sub> absorbs light in the range of 380 – 400 nm corresponding to band-gap of ca. 3.2 – 3.1 eV and loading of Cu increases the absorption. The feed stock Cu-NPs are close to spherical in shape and their size lies in the range of 2.5 - 10 nm. The finger spacing of 0.35 nm and 0.207 nm were indexed to the (101) lattice plane of anatase TiO<sub>2</sub> and Cu (111) planes. In XP spectra of 2% Cu-Oxi/TiO<sub>2</sub> has a peak at 934.4 eV belonging to 2p<sub>3/2</sub> of Cu<sup>2+</sup> in CuO and a broad satellite peak of weak intensity at 943.8 eV, 2p<sub>1/2</sub> peak characteristic of the presence of Cu<sup>2+</sup> species.

The prepared photocatalyst were tested for CO<sub>2</sub> photoreduction under UV C irradiation in a continuous gas phase reactor. The 1% Cu-Red/TiO<sub>2</sub> is considered as best catalyst in terms of CO and H<sub>2</sub> formation with rate 334 μmol g<sup>-1</sup>h<sup>-1</sup> and 452 μmol g<sup>-1</sup>h<sup>-1</sup> respectively.

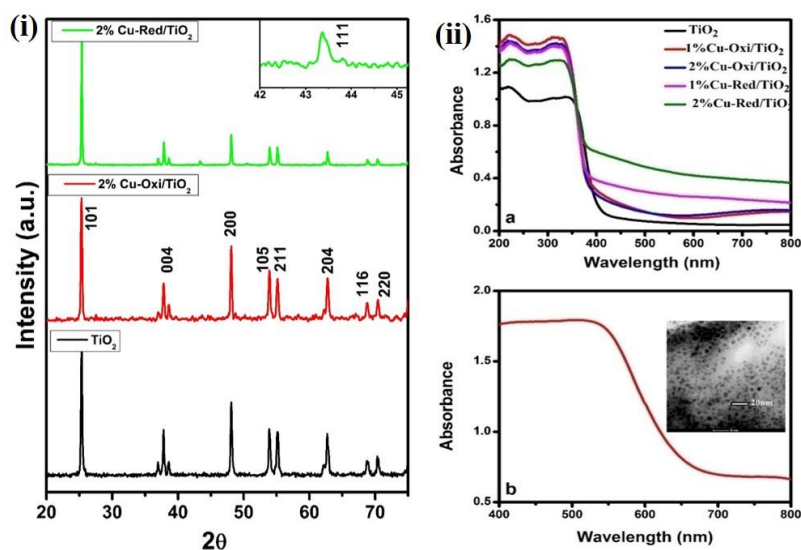


Figure 1. (i) XRD of Cu/TiO<sub>2</sub> (ii) Electronic spectra of (a) TiO<sub>2</sub> and Cu-NPs loaded TiO<sub>2</sub>; (b) Cu-NPs

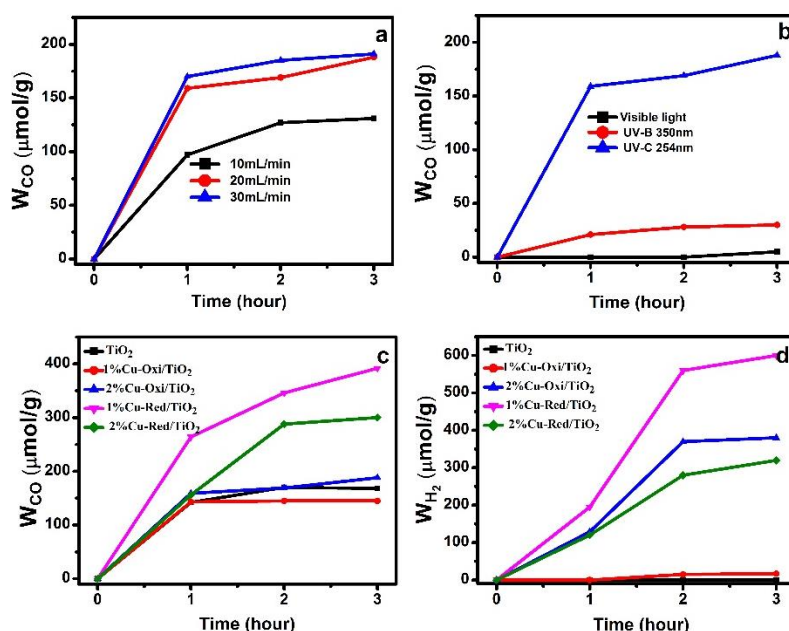


Figure 2. Product formation during photocatalytic reduction of CO<sub>2</sub> over 3 h of irradiation: (a) CO production with different flow rate over 2% Cu-Oxi/TiO<sub>2</sub>; (b) CO production with different light sources over 2% Cu-Oxi/TiO<sub>2</sub>; (c) CO production over different photocatalysts; (d) H<sub>2</sub> production over different photocatalysts under UV-C light.

**Funding:** CSIR (Grant Serial 1121110360, Ref-18-12/2011(ii)EU-V).

**Acknowledgement:** We thank Director IIP, and analytical Science division, CSIR-IIP. N.S. is thankful to CSIR for funding.

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