Continuous hydrothermal decomposition of liquid effluent into high-value carbon and hydrogen

Vikas Patel1, Sivamohan N. Reddy1
1Indian Institute of Technology Roorkee, Roorkee, Uttarakhand, India
V_patel@ch.iitr.ac.in

The sustainable treatment and valorization of liquid effluent is essential for advancing the circular economy and low-carbon energy system. This study uniquely demonstrates the continuous hydrothermal synthesis of carbon nanotubes by leveraging the solubility properties of the carbon precursor, performed both with and without a catalyst. This study proposes a straightforward, single-step synthesis method that outperforms conventional gas-phase synthesis methods. In this work, ethanol was used as a carbon source, while heavy metals such as nickel, zinc, and copper were employed as catalysts to promote the formation of nanotubes. The morphological and structural properties of nanotubes were investigated using high-resolution transmission electron microscopy, scanning electron microscopy, XRD, XPS, and Raman analysis. The produced nanotubes are wavy-shaped, multi-walled structures with diameters ranging from 10 to 35 nm at a temperature of 600 °C and a pressure of 240 bar. Apart from carbon nanotubes, hydrogen-rich fuel gas has been produced, which is composed mostly of nearly 62 vol.% hydrogen, followed by methane and carbon dioxide. Therefore, the growth of nanotubes in the liquid phase on the metal surface has been corroborated within a highly reactive supercritical water medium. This process involves the dissolution and precipitation interactions between the metal and the carbon precursor, leading to the formation of metal carbide, which subsequently facilitates the formation of nanotubes.

References

[1] Jie et al., Nature Catalysis, 3(11) 902-912 [2020].
[2] Liu et al., Nature Communications, 13(1), 5755 [2022].

Figures

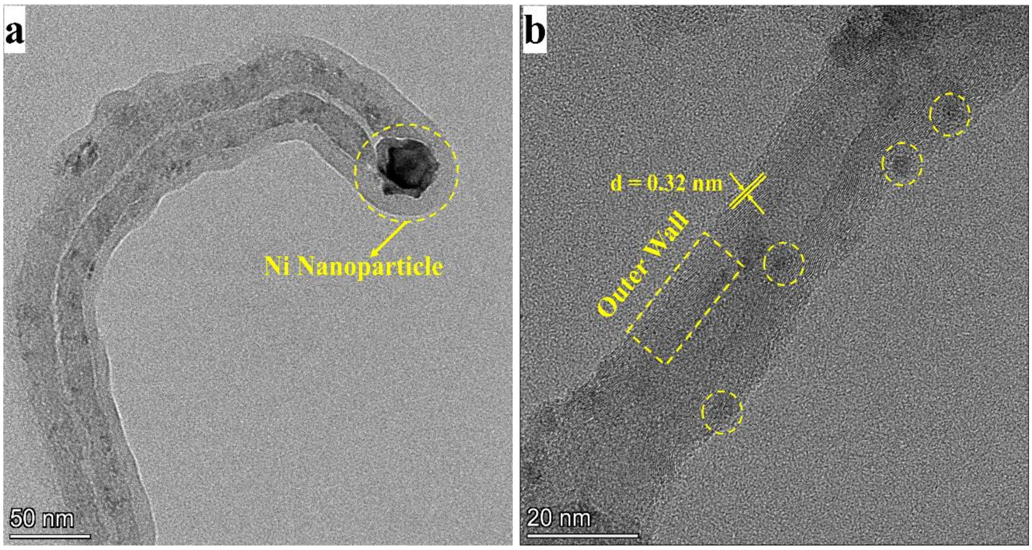

Figure 1: HR-TEM image of Ni/MWCNTs. a: Entrapped Ni nanoparticle at the CNT tip, b: A high magnification TEM image showing the outer wall and lattice fringes, as well as encapsulated Ni particles shown in a circle.