

## Single-Walled Carbon Nanotube Synthesis by Chemical Vapor Deposition Using Platinum-Group Metal Catalysts

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**Abstract :** Single-walled carbon nanotubes (SWCNTs) are generally synthesized by chemical vapor deposition (CVD) using Fe, Co, and Ni as catalysts. However, due to the Ostwald ripening of metal catalysts, the diameter distribution of the grown SWCNTs is considerably wide ( $>2$  nm), which is not suitable for electronics applications. In addition, reduction in the growth temperature is desirable for fabricating SWCNT devices compatible with the LSI process. Herein, we performed SWCNT growth by alcohol catalytic CVD using platinum-group metal catalysts (Pt, Rh, and Pd) because these metals have high melting points, and the reduction in the Ostwald ripening of catalyst particles is expected. Our results revealed that web-like SWCNTs were obtained from Pt and Rh catalysts at growth temperature between  $500\text{ }^{\circ}\text{C}$  and  $600\text{ }^{\circ}\text{C}$  by optimizing the ethanol pressure. The SWCNT yield from Pd catalysts was considerably low. By decreasing the growth temperature, the diameter and chirality distribution of SWCNTs from Pt and Rh catalysts became small and narrow. In particular, the diameters of most SWCNTs grown using Pt catalysts were below 1 nm and their diameter distribution was considerably narrow. On the contrary, SWCNTs can grow from Rh catalysts even at  $300\text{ }^{\circ}\text{C}$  by optimizing the growth condition, which is the lowest temperature recorded for SWCNT growth. Our results demonstrated that platinum-group metals are useful for the growth of small-diameter SWCNTs and facilitate low-temperature growth.

**Keywords :** carbon nanotube, chemical vapor deposition, catalyst, platinum, rhodium, palladium

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