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Perspective

# Carbon Nanotubes for Separation and Purification Techniques

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## DESCRIPTION

Despite their one-dimensional form, Carbon nanotubes (CNTs) are tube-like rolled-up graphene sheets with unique electrical and optical capabilities. The high electrical conductivity, thermal conductivity, and mechanical strength of the materials were used to evaluate their commercialization potential. Single-walled CNTs (SWNTs), Double-walled CNTs (DWNTs), and Multi-walled CNTs (MWNTs) are the three types of carbon nanotubes. SWNTs have a high degree of transparency, outstanding physical qualities, and are lightweight. SWNTs' most important attributes are their metallic or semiconducting electrical properties, which vary depending on chirality and diameter; DWNTs and MWNTs, on the other hand, have primarily metallic properties. For metallic characteristics, the chirality of SWNTs (i.e., the vector (n, m) in the direction in which the sheet is rolled up) is $n-m=3q$ ($q=0$ or positive integer), and for semiconducting qualities, any other value.

Fuel cells, flexible electronic devices, transparent conducting materials, reinforcing materials, transistors, solar cells, and medicinal materials can all benefit from SWNTs. SWNTs must be differentiated by using their electrical (i.e., metallic or semiconducting) qualities to improve their performance in applications since metallic and semiconducting SWNTs cannot be manufactured separately. Different SWNT separation techniques have been investigated, including density gradient ultracentrifugation, electrophoresis, selective SWNT destruction, and DNA or polymer wrapping. To allow the high-purity separation of metallic SWNTs (m-SWNTs) and semiconducting SWNTs, a variety of separation methods have been developed (s-SWNTs).

Gel chromatography and aqueous two-phase extraction (ATPE) have been presented as commercially viable large-scale separation procedures. Single-chirality separation and m/s separation of various SWNTs are also possible with ATPE. However, there are challenges to be resolved; its separation efficiency is heavily impacted by minor changes in experimental circumstances such as temperature, and removing polymers from SWNTs is challenging. Researchers have investigated a wide range of gel-based separation methods for SWNT separation since gel chromatography may be utilised for both simultaneous high-purity separation of m/s-SWNTs and chirality-specific separation of SWNTs using a comparatively easy approach over the ATPE method. Researchers proposed using Controlled Porous Glass (CPG) as a medium to separate SWNTs in 1998. For length sorting and m/s-SWNT separation, silica gel and High-Performance Liquid Chromatography (HPLC) equipment were utilised. SWNTs are functionalized or wrapped with DNA to create solutions with dispersed SWNTs in the separation with CPG and silica gel. Polysaccharide hydrogels, such as agarose and allyl dextran-based gels, have been employed as separation mediums since 2009, with many successful SWNT separations reported. The SWNT-surfactant aqueous solutions were employed as feed samples in hydrogel-based separations, and the SWNT separation mechanism was investigated using the interaction of the surfactant–SWNT assembly with the gel.

Adsorption, rinsing, and elution are the three phases of the typical SWNT separation process using hydrogel and anionic surfactant-based chromatography. The SWNT–surfactant aqueous solution is first applied to the gel and adsorbed. At first, m-SWNTs that had not been adsorbed by the gel were eluted. Second, a little amount of surfactant aqueous solution is introduced into the gel to elute any remaining SWNTs that have been weakly adsorbed by the gel. If the gel capacity is large enough, m-SWNTs can be eluted by a surfactant aqueous solution injection.

Finally, a surfactant aqueous solution with a high concentration of surfactant is introduced into the gel to elute the s-SWNTs that have been heavily adsorbed by the gel. The varying quantities of surfactants on the m- and s-SWNTs cause the gel and surfactant–SWNT assembly to have distinct adsorption strengths. Surfactants hinder SWNTs from connecting to gels; as the surface area of SWNTs covered by surfactants increases, the adsorption strength between SWNTs and gels decreases.

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