

# Preparation and characterization of poly(styrene-*co*-butyl acrylate)-encapsulated single-walled carbon nanotubes under ultrasonic irradiation

Min Nie · Hesheng Xia · Jinkui Wu

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**Abstract** Polymeric composite materials filled with single-walled carbon nanotubes (SWNTs) have attracted much attention, but successful applications of such composites require uniform dispersion of SWNTs in the polymeric matrix and the strong SWNTs-polymer interface interaction. In this paper, chemical modification combined with ultrasonically initiated in situ polymerization was successfully employed to prepare poly(styrene-*co*-butyl acrylate)/single-walled carbon nanotubes composites [P(St-BA)/SWNTs]. The whole procedure contained two steps: in the first step, 3-(trimethoxy)-propylmethacrylate-silane (silane-coupling agent, KH570), a kind of polymerizable vinyl monomer, was grafted onto the surface of SWNTs, forming KH570-g-SWNTs by reacting KH570 with hydroxyl groups on the surface of SWNTs, which was proved by combination of FTIR and XPS results. Due to the presence of polymerizable KH570 on the surface of SWNTs, this provides a basis for the next stage of polymerization to prepare polymer-encapsulated SWNTs composites. In the second step, an ultrasonically initiated in situ emulsion polymerization of monomer styrene (St) and *n*-butyl acrylate (BA) proceeded in the presence of KH570-g-SWNTs. Consequently, P(St-BA)/SWNTs composite emulsion was obtained. TEM confirmed that SWNTs were coated with the obtained polymer. FTIR and XPS further showed that even after 72 h of Soxhlet extraction with boiling toluene, there were still unextracted polymers in P(St-BA)/SWNTs

composite, indicating strong interaction between the polymer and carbon nanotubes. Finally, a mechanism for formation of polymer-encapsulated SWNTs through ultrasonically initiated in situ emulsion polymerization was proposed. This study could provide a new way to resolve the problems of the dispersion, stabilization, and compositing of SWNTs with polymer matrix and prepare polymer/SWNTs composites.

**Keywords** Ultrasonic irradiation · In situ polymerization · Modification · Carbon nanotubes · Emulsion polymerization

## Introduction

Single-walled carbon nanotubes (SWNTs) are fascinating materials with remarkable electrical and mechanical properties coupled with good chemical stability [1–3]. Thus, polymeric composite materials filled with SWNTs have attracted much attention [4–6], but successful applications of such composites require: (1) uniform dispersion of SWNTs in the polymeric matrix, and (2) strong SWNTs-polymer interface interaction. Up to now, many approaches have been developed to solve the above problems so as to prepare SWNTs/polymer composites, by in situ polymerization [7–10], solution mixing and casting [11], melt blending [12, 13], etc.

Among these approaches, in situ polymerization is one of the most important approaches due to the strong covalent bonding between the grafted polymer and SWNTs. Haggenueller et al. [14] adopted an interfacial polymerization method for nylon 6,6 to produce nanocomposites with SWNTs. Viswanathan et al. [9] synthesized polystyrene/SWNTs composites by single-step

M. Nie · H. Xia (✉) · J. Wu  
State Key Laboratory of Polymer Materials Engineering,  
Polymer Research Institute of Sichuan University,  
Chengdu 610065, China  
e-mail: poly.nie@gmail.com