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A Study of the Flow Behavior of Prevulcanised Natural Rubber Latex/singlewalled Carbon Nanotubes (SWCNT) Blends Using Rotational Viscometry and Power Law Model

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Abstract:
This work describes the flow behavior of prevulcanised natural rubber latex (PvNRL) and PvNRL nanoblends containing 0.02, 0.04, 0.06, and 0.08 wt.% of aqueous dispersion of single-walled carbon nanotubes (SWCNT). The assay was performed under varying shear rates (between 0.1 – 100 1/s) at three separate isothermal temperatures (25, 30, and 35 °C) on a Modular Compact Rheometer (MCR) fitted with a concentric cylinder measuring system. A steady decrease in viscosity upon every single shear rate increment was observed for all the samples analysed. Thus, each measured viscosity was considered an apparent-viscosity; which confirms a typical non-Newtonian flow behavior. PvNRL blends containing highest wt.% SWCNT exhibited higher apparent viscosity at low shear rates, whereas the lowest wt.% SWCNT displayed a lower apparent viscosity, thus signifying a dilution effect. The power law model showed good fitting and successfully predicted the flow behavior within the modelled shear rate region.

Key words:
Prevulcanised natural rubber latex, single-walled carbon nanotubes, flow behavior, shear rate, apparent viscosity, non-Newtonian, shear-thinning

1 INTRODUCTION

The exceptional properties of nanomaterials and their vast application potential has raised great interests, especially in the preparation of natural rubber latex (NRL) nanocomposites [1, 2]. For instance, single-walled carbon nanotubes (SWCNT), have been found to perform as excellent reinforcing filler for NRL at very low loadings due to their high aspect ratio and excellent strength [1, 3]. However, the sp2 hybridized SWCNT are largely insoluble in water and hence require special functionalisation to achieve the desired solubility [1, 2, 4]. Covalent functionalisation involves the introduction of suitable functional groups on the surface of nanomaterials; however, this method comes at the expense of compromising the structure of pristine SWCNT [5]. Non-covalent functionalisation involves either establishing hydrophobic interaction between an amphiphilic surfactant and the nanomaterial or via enthalpy-driven interactions such as π-π, CH-π, NH-π in order to promote solvation [1, 6 – 8]. Some of the most commonly used molecules for non-covalent dispersion of SWCNT include: sodium dodecyl sulfate (SDS), sodium dodecylbenzene sulfonate (SDBS) and sodium carboxymethyl cellulose (NaCMC). These surfactant systems are preferred because they are water soluble and possess relatively high content of Hydrophyle-Lyphophyle blance (HLB) [9]. It is generally understood that the hydrophobic portion of the amphiphilic surfactant molecule adsorbs onto the surface of SWCNT, and the hydrophilic

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