ABSTRACT

The present research work reports development of stable fullerene C_{60}:poly(vinyl pyrrolidone) PVP and Au reinforced C_{60}:PVP nanofluids (NFs) and their characterization in terms of optical, electro-kinetic, microstructure, and rheological properties in *n*-butanol and water. A simple non-covalent surface modification route is used in solubilizing C_{60} molecules as large as 69.5 µmol/L in presence of 1.1 M PVP in *n*-butanol. A simple in-situ $Au^{3+} \rightarrow Au$ reaction is carried out by adding an Au $(NO_3)_3$ salt solution in water to a C_{60}:PVP solution consisting of 2.0 µmol/L C_{60} with 40.0 g/L PVP drop by drop at 50-60 ^{0}C with an ultrasonic irradiation. The nanogold so appears upon chemical reduction gets dispersed via exfoliated PVP and results in a stable nanofluid. The Au-content is varied in small steps of 0.85, 1.7, 4.2, 8.4, 17.0, 42.0, and 85.0 µmol/L in tuning the rheology and optical properties suitable for biosensors, energy storage materials, light harvesting devices, biomedicals, and other applications. The results so obtained are described in four chapters as follows.

Chapter-1 gives a brief introduction to different kinds of nanostructured materials along with typical properties and applications. It includes an extensive literature survey of studies reported on the methods for synthesis of C_{60}:PVP and Au: C_{60}:PVP NFs and their typical properties and applications. A statement of the problem is made according to the work done so far in this discipline along with the motivation behind choosing this research work and several intriguing properties for open applications. Experimental methods used in part of the characterization with UV-Visible absorption spectra, IR absorption spectra, Raman spectra, light-emission spectra, dynamic light scattering (DLS), zeta potential, and rheology are described in Chapter-2. Plausible mechanisms of solubilization and stabilization of C_{60} molecules in the presence of PVP in the two carriers in support of experimental findings are briefed in Chapter-3, with the results of optical and rheological properties in C_{60}:PVP NFs in the two carriers discussed in Chapter-4. A donor-acceptor energy transfer PVP $\rightarrow$ C_{60} incurs with enhancement in intensity of selective vibration bands, while a decrease in the light emission in the PVP moieties in a charge transfer complex. The C_{60}:PVP NFs perceive non-Newtonian behavior in both the media. The shear viscosity relaxes slowly to the base value on increasing the shear rate from 10 to 100 s^{-1} as it refines the C_{60}-PVP complex in small structures.

Chapter-5 deals with DLS bands and zeta potential in C_{60}:PVP NFs in the two media. An analysis of DLS data in terms of polydispersity index reveals a well dispersed structure of C_{60} small assemblies with PVP molecules in both the liquid carriers. The results of optical and rheology in Au reinforced C_{60}:PVP NFs in water are presented in Chapter-6. An inclusion of nanogold into a C_{60}:PVP nanofluid results in an Au-SPR enhanced $\pi \rightarrow \pi^*$ $C_{60}(sp^2)$ electron transition over 250–450 nm of absorption spectrum in water. A rheological study performed on the Au:C_{60}-PVP NFs in water by varying the Au-content up to 85.0 µmol/L reveals a non-Newtonian behavior with a residual yield stress. Finally, a summary of the work with salient features achieved in this work is given in the last Chapter-7 along with a future scope of the work in this series of NFs.

Keywords: Fullerene; Nanofluids; Poly(vinyl pyrrolidone); Charge transfer bands; SPR bands, Light – emissions; Reinforced nanocomposites