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Research article

Enhanced structural, thermal, mechanical and electrical properties of nano ZTA/epoxy composites

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Supplementary

1. Materials and methods

Optical diffuse reflectance measurements were carried out with a Perkin-Elmer UV/VIS Lambda 365 within a wavelength range of 200–1100 nm. Raman spectrometer LabRAM HR (Horiba Jobin Yvon, France) was employed for recording the Raman spectra with an excitation wavelength of 532 nm.

2. Raman Spectroscopy

Raman spectroscopy was used to find the vibrational modes, optical properties and for better understanding of the presence of t-ZrO_2 and α-alumina in the nanopowder and the epoxy composites. Figure S1 reveals the Raman spectrum of ZTA nanopowder with highly prominent zirconia peaks existing in tetragonal phase and lesser prominent peaks of alumina existing in alpha phase. The results obtained are in good agreement with XRD results. Raman bands of tetragonal and alpha alumina polymorphs are labelled as **t** and **α** respectively. Sharp prominent peaks of t-ZrO_2 were obtained at 145 cm^{-1}, 270 cm^{-1}, 315 cm^{-1} and 456 cm^{-1}. Strong peaks of α-Al_2O_3 were observed at 380 cm^{-1} and 416 cm^{-1}. t-ZrO_2 and α-Al_2O_3 were found to co-exist at 647 cm^{-1}. All the peak positions obtained matched well with literature values [1–3]. Strong E_g vibrational mode of t-ZrO_2 was observed at 145 cm^{-1}. The Raman bands obtained at different Raman intensity indicate large active sites and fluorescence formed due to the formation of hot spots that lead to enhanced Raman scattering effect.

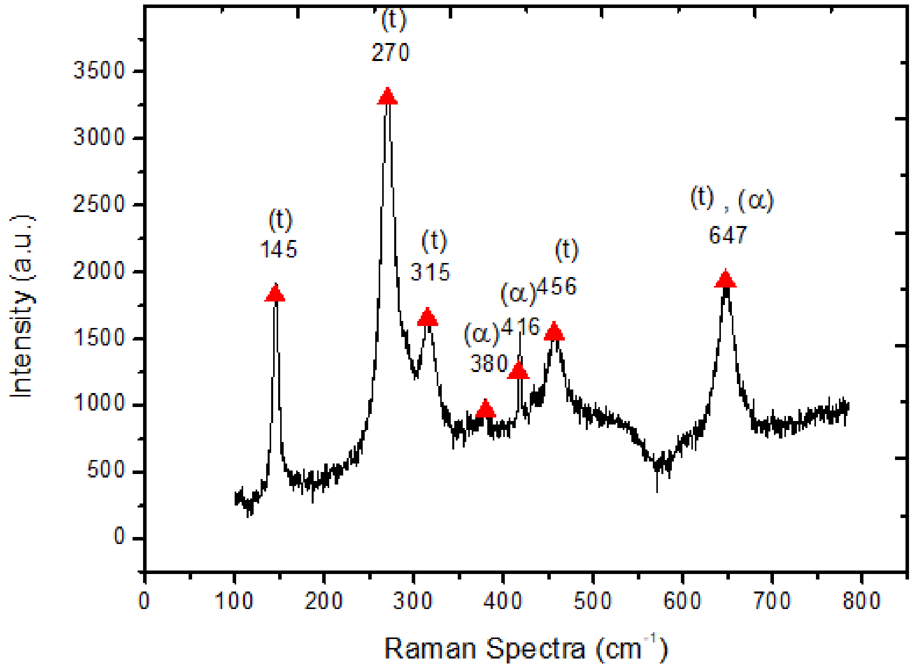

Figure S1. Raman Spectra of ZTA nanopowder.

To explore, compare and correlate the Raman spectroscopy of epoxy composites, plain epoxy was doped with varying concentrations of ZTA nanopowder. The results shown in Figure S2 indicate that there was a significant increase of 39.13% increase in Raman intensity compared to plain epoxy. The Raman signal enhancement is observed to be the highest for epoxy with 2.5 wt% ZTA. This remarkable improvement indicates that there is a large increase in the active sites which has led to Raman signal enhancement, enhanced Raman scattering and fluorescence in the epoxy composites [4]. These results suggest that the nano ZTA/epoxy composites exhibit outstanding optical properties.

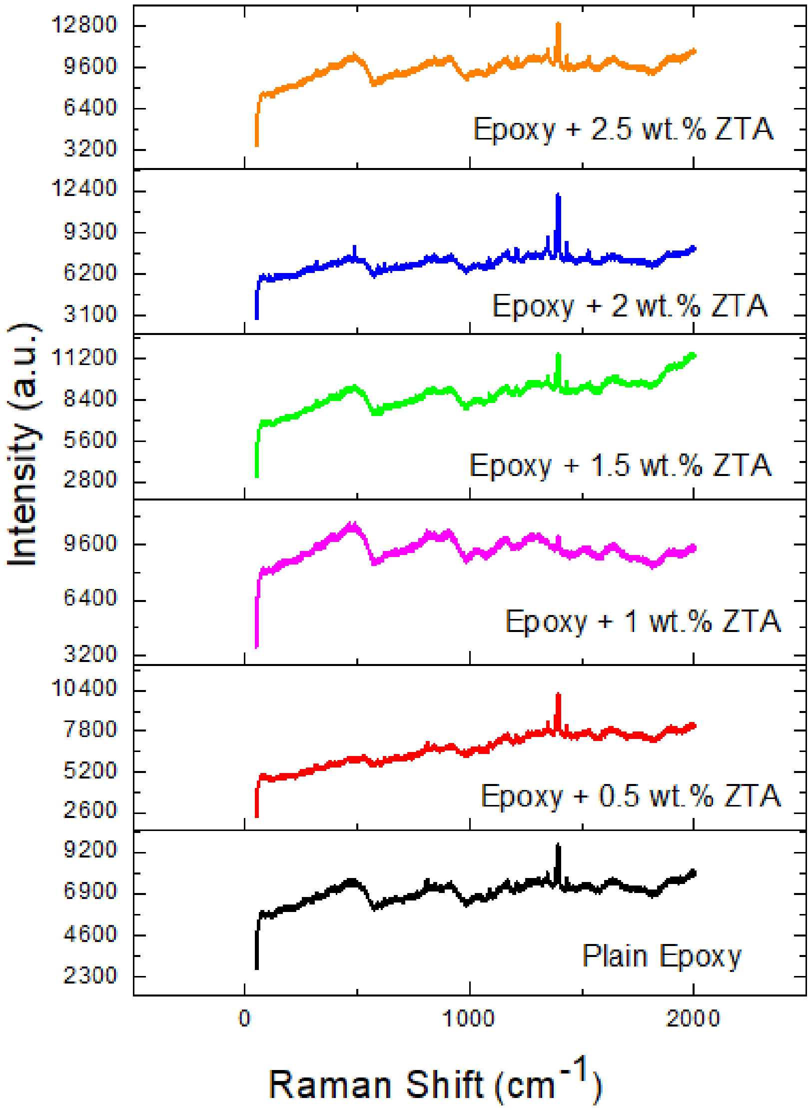

Figure S2. Raman spectroscopy of plain epoxy and nano ZTA/epoxy composites.

3. UV-Vis Spectra

UV-Vis spectra of ZTA nanopowder is as shown in Figure S3. At very low wavelength ranging from 200–300 nm the transmittance also remains low (0–20%) for ZTA nanopowder, as the wavelength increased from 300–1100 nm a steep increase in transmittance was also observed. Low transmittance of UV light through the nanopowder at low wavelength indicates that the sample exhibits high UV-Shielding capacity. Li et al. [5] found that samples that are calcinated at temperatures ranging between 400–600 °C exhibit excellent UV-Shielding efficiency than samples that calcinated at low temperatures (<350 °C).

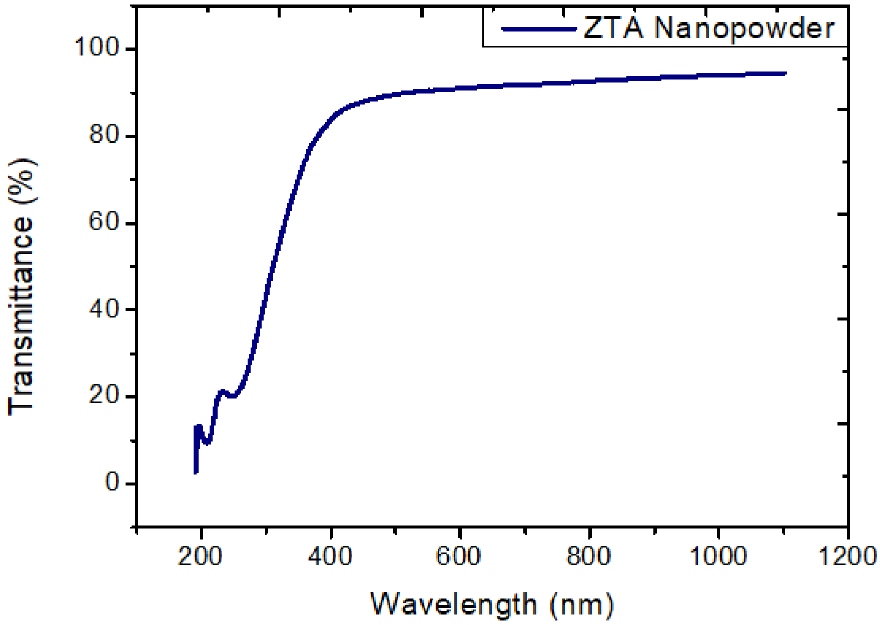

Figure S3. UV-Vis Spectra of ZTA nanopowder.

Figure S4 shows the UV-Vis spectra of plain epoxy and nano ZTA/epoxy composites. It is observed that, plain epoxy showed 0% transmittance of UV light in the wavelength range upto 300 nm, after which an exponential increase in the transmittance of UV light through the sample was observed. UV shielding efficiency of plain epoxy sample was found to around ~40% at high wavelengths ranging from 800–1100 nm. Addition of ZTA nanoparticles decreased the transmittance through the epoxy composites to a great extent, the transmittance of UV light through all the epoxy composites remained ~0% upto a wavelength of 400 nm (Figure S4). Lowest transmittance (~5%) of UV light through the epoxy composites was observed in epoxy loaded with 2.5 wt% ZTA nanoparticles. This proves that epoxy loaded with 2.5% ZTA exhibits excellent UV shielding efficiency among all the samples at a very wide wavelength range (200–1100 nm). Even though the samples showed high UV efficiency, the visible light transparency of the epoxy composites decreased with increase in nano filler content in epoxy.

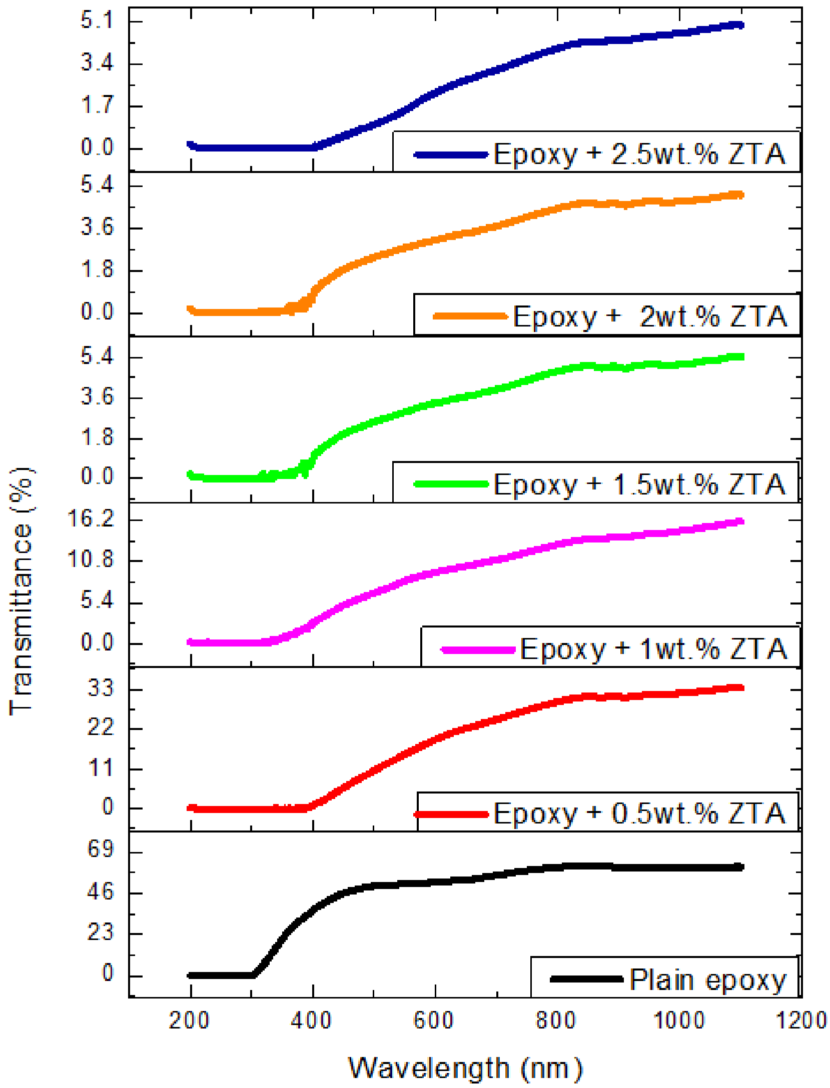

Figure S4. UV-Vis Spectra of plain epoxy and nano ZTA/epoxy composites.

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