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Supplementary Information

Effect of MWCNT Nanofiller on the Dielectric Performance of Bio-inspired Gelatin Based Nanocomposite

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1. Thermal properties

1.1 Characterization

Differential scanning calorimetric (DSC) analysis was used to investigate the thermal characteristics of Gel/MWCNT nanocomposites. The samples were heated from 30 to 350 degrees Celsius for DSC analysis. To avoid degradation induced by the thermo-oxidative process, the samples were heated at a rate of 10 °C/min and held in a nitrogen environment at a flow rate of 50 ml/minute each time.

1.2 Thermal property analysis

Differential Scanning Calorimetry (DSC) was carried out to observe the effect of MWCNT on the thermal property of the gelatin biopolymer. The obtained DSC curves are shown in figure S1 and the thermal transition parameters of the nanocomposites extracted from the graph are listed in table S1. From the figure, it is observed that the thermal decomposition of the nanocomposites took place through several stages. Figure S1 presents an endothermic peak in the vicinity of 70 °C on account of continuous loss of moisture. The obtained glass transition temperature (T_g) was 79.5 ˚C for the Pure Gel which decreased slightly due to the addition of glycerol plasticizer [1] but

then increased with the incorporation of the MWCNT filler in the plasticized polymer. As observed, the T_g was found at 73.7 °C for the Gel/0.05 wt% MWCNT sample. At, 180 °C, the endothermic peak appears for the melting of dried gelatin. It was reported that the dried gelatin specimens undergo tertiary structure transformation and oxidation in air at the melting temperature (T_m) [2]. The melting enthalpy (ΔH_m) was calculated using the integrated area under the melting peak [3]. ΔH_m increased by a factor of 10 with upto 0.02 wt% of MWCNT incorporation into the gelatin matrix and above that concentration, this value decreased. After the nanocomposites have finished the structure transformation, from 200 °C to 350 °C was associated with protein degradation of the biopolymer. The splitting of peptide linkages of proteins starts approximately at 250 °C for the nanocomposites and is indicated by a broad endothermic peak. From the results, it is observed that up to 0.02 wt% MWCNT loading, decomposition enthalpy (ΔH_d) as well as the corresponding decomposition temperature (T_d) increased which is a good indication of improved thermal stability [4]. But beyond 0.02 wt% MWCNT loading, the maximum decomposition rate started to increase and the corresponding decomposition temperature decreased. The reason behind this behavior is that beyond 0.02 wt% MWCNT loading, interfacial bonding between MWCNT and Gel matrix was poor due to a considerable amount of MWCNT agglomeration which has been cleared from SEM analysis. The melting enthalpy and decomposition enthalpy indicate improved thermal behavior with increasing filler as high as 0.02 wt% because of the well dispersion to showcase the extraordinary thermal characteristics of the MWCNTs and then the agglomeration of the fillers in the highest concentration hinders the thermal performance of the nanocomposite.

Reference

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Table S1. Different parameters obtained from the DSC analysis of the Gelatin/MWCNT composites

Sample	Glass Transition Temperature, T_g (°C)	Melting Peak Temperature, T_m (°C)	Enthalpy of Melting, ΔH_m (J/g)	Decomposition Peak Temperature, T_d (°C)	Enthalpy of Decomposition, ΔH_d (J/g)
Gel	79.5	180	13.7	207	8
Gel/0.005% MWCNT	63.2	137	29.5	251	100.5
Gel/0.01% MWCNT	66.3	139	42.0	256	146.4
Gel/0.02% MWCNT	69.4	140	140	287	216.5
Gel/0.05% MWCNT	73.7	141	42.5	252	134.3

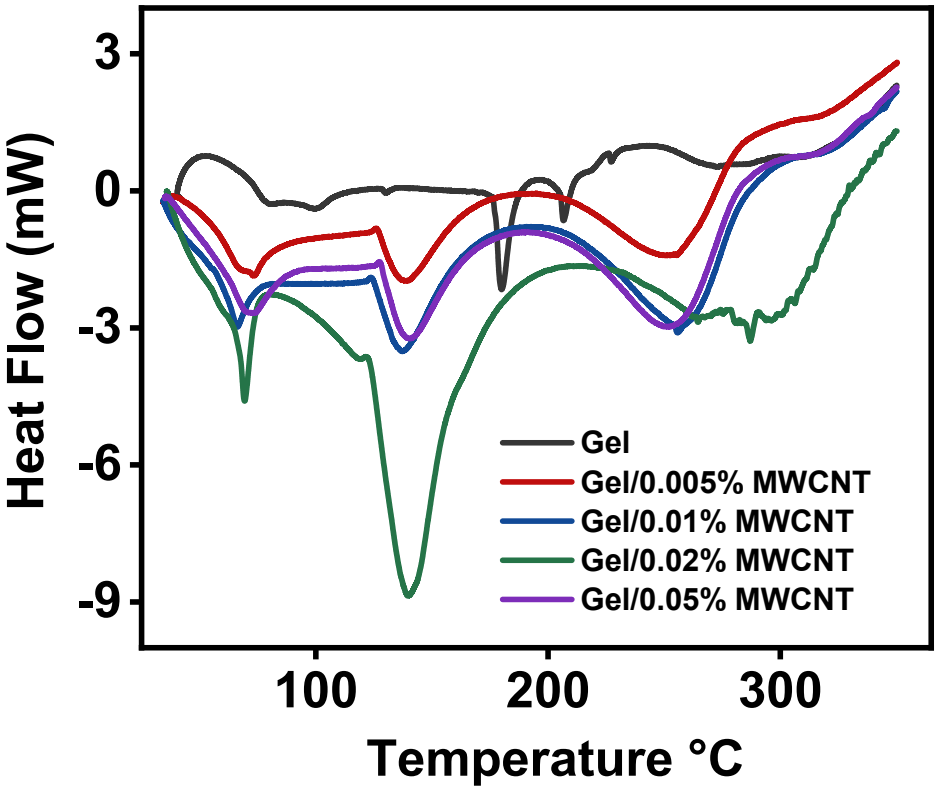

Figure S1. DSC curves for the Pure Gelatin and Gelatin/MWCNT nanocomposites in the temperature ranges from 30 ˚C to 350 ˚C.