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Characterization of Physical and Thermal Properties of Biofield Treated Neopentyl Glycol

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Abstract

Neopentyl glycol (NPG) has been extensively used as solid-solid phase change materials (PCMs) for thermal energy storage applications. The objective of the present study was to evaluate the impact of biofield treatment on physical, spectral and thermal properties of NPG. The study was performed in two groups (control and treated). The control group remained as untreated, and treatment group was subjected to Mr. Trivedi's biofield treatment. The control and treated NPG were characterized by X-ray diffraction (XRD), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), and Fourier transform infrared (FT-IR) spectroscopy. XRD study revealed the decrease in crystallite size of treated NPG by 21.97% as compared to control sample. DSC studies showed slight change in melting temperature of treated NPG as compared to control sample. TGA analysis showed 55.66% weight loss in control NPG however, the treated sample showed reduction in weight loss (44.81%). Additionally, the maximum thermal decomposition temperature (Tmax) of treated NPG (160.40°C) was minimally increased with respect to control sample (159.72°C). This can be inferred as good thermal stability of biofield treated NPG with respect to control. FT-IR spectroscopy showed no structural changes in treated NPG with respect to control sample. The overall results showed that biofield treatment has affected the physical and thermal properties of treated NPG. Moreover, good thermal stability of treated NPG showed that it could be used as phase change materials for thermal energy storage applications.

Keywords: Neopentyl glycol; X-ray diffraction; Differential scanning calorimetry; Thermogravimetric analysis; Fourier transform infrared spectroscopy

Abbreviations

NPG: Neopentyl glycol; XRD: X-ray diffraction; DSC: Differential scanning calorimetry; TGA: Thermo gravimetric analysis; DTA: Differential thermal analysis; FT-IR: Fourier transform infrared; PCMs: Phase Change Materials; LTHS: latent heat storage devices

Introduction

The global price rise of petroleum products and fossil fuel has led scientists to design new strategies for thermal energy regeneration and conservation. The latent heat storage devices (LTHS) prepared from phase change materials (PCMs) are interesting choice for thermal energy storage applications. The LTHS are widely used in several applications such as condensation heat recovery, building energy conservation, temperature regulating textiles and solar energy systems [1-4]. Many compounds have been used recently for fabricating the LTHS i.e., fatty acids, poly ethylene glycol (PEG), alcohols and mixture of them. Several types of PCMs are available these days such as solid liquid PCMs, solid-solid PCMs and liquid-gas PCMs [5,6].

Recently polyalcohols have gained significant attention as PCMs. PEG is commonly used as solid liquid PCM owing to its excellent properties such as, high latent heat of fusion, suitable melting point, and being chemically inert and stable [7-9]. Feng et al. had prepared polyethylene glycol/active carbon composites as shape stabilized PCMs [10]. Similarly neopentyl glycol (NPG) was also investigated as potential material for solid-solid PCMs [11]. Hence, by considering the phase change property of NPG, authors decided to investigate the influence of biofield treatment on its physical, spectral and thermal properties which could be further utilized for thermal storage applications.

It has been stated that energy exist in various forms such as kinetic, potential, electrical, magnetic, nuclear etc. which have been generated from different sources. Similarly, neurons which are present in human brain have the ability to transmit the information in the form of electrical signals [12-15]. Thus, human has the ability to harness the energy from environment/Universe and can transmit into any object (living or non-living) around the Globe. The object(s) always receive the energy and responded into a useful manner that is called biofield energy. This whole process is known as biofield treatment. Mr. Trivedi's biofield treatment (The Trivedi Effect®) is known to transform the characteristics of various living and nonliving things. The biofield treatment has altered the physical and thermal properties in metals [16-19], improved the growth and production of agriculture crops [20-23] and significantly altered the phenotypic characteristics of various pathogenic microbes [24-26]. Additionally, biofield treatment has substantially altered the medicinal, growth and anatomical properties of ashwagandha [27].

Based on excellent outcome from biofield treatment and phase change property of NPG, the present work was undertaken to investigate the impact of biofield on physical, spectroscopic and thermal properties of NPG.

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Materials and Methods

Neopentyl glycol was procured from S D Fine Chemicals Limited, India. The sample was divided into two parts; one was kept as a control sample, while the other was subjected to Mr. Trivedi's biofield treatment and coded as treated sample. The treatment group was in sealed pack and handed over to Mr. Trivedi for biofield treatment under laboratory condition. Mr. Trivedi provided the treatment through his energy transmission process to the treated group without touching the sample. The control and treated samples were characterized by XRD, DSC, TGA and FT-IR techniques.

Characterization

X-ray diffraction (XRD) study: XRD analysis of control and treated NPG was carried out on Phillips, Holland PW 1710 X-ray diffractometer system, which had a copper anode with nickel filter. The radiation of wavelength used by the XRD system was 1.54056 Å. The data obtained from this XRD were in the form of a chart of 2θ vs. intensity and a detailed table containing peak intensity counts, d value (Å), peak width (θ°), relative intensity (%) etc. The crystallite size (G) was calculated by using formula:

$$G=k\lambda/(b\cos\theta)$$

Here, λ is the wavelength of radiation used, b is full width half maximum (FWHM) of peaks and k is the equipment constant (k=0.94). Percentage change in crystallite size was calculated using following formula:

$$\text{Percentage change in crystallite size}=[(G_t-G_c)/G_c]\times 100$$

Where, G_c and G_t are crystallite size of control and treated powder samples respectively.

Differential scanning calorimetry (DSC) study: DSC was used to investigate the melting temperature and latent heat of fusion (ΔH) of samples. The control and treated NPG samples were analyzed by using a Pyris-6 Perkin Elmer DSC on a heating rate of 10°C/min under air atmosphere and air was flushed at a flow rate of 5 mL/min.

Percentage change in ΔH was calculated using following equations:

$$\%\ \text{change in Latent heat of fusion}=\frac{[\Delta H_{\text{Treated}}-\Delta H_{\text{Control}}]}{\Delta H_{\text{Control}}}\times 100$$

Where, $\Delta H_{\text{Control}}$ and $\Delta H_{\text{Treated}}$ are the latent heat of fusion of control and treated samples, respectively.

Thermo gravimetric analysis-differential thermal analysis (TGA-DTA): Thermal stability of control and treated NPG were analyzed by using Mettler Toledo simultaneous TGA and Differential thermal analyzer (DTA). The samples were heated from room temperature to 400°C with a heating rate of 5°C/min under air atmosphere.

FT-IR spectroscopy: FT-IR spectra were recorded on Shimadzu's Fourier transform infrared spectrometer (Japan) with frequency range of 4000-500 cm^{-1}. The treated sample was divided in two parts T1 and T2 for FT-IR analysis.

Results and Discussion

XRD Study

The XRD diffractogram of control and treated NPG are presented in Figure 1. The XRD of control NPG showed presence of intense XRD peaks at 2θ equals to 11.82°, 11.98°, 18.07°, 18.48°, 42.26° and 42.39°. This showed the crystalline nature of control NPG. However, the treated NPG showed XRD peaks at 2θ equals to 11.96°, 16.22° and 18.42°. The result showed increase in intensity of treated NPG as compared to control sample which may be correlated to increase in crystallinity of the sample. It is hypothesized that biofield treatment may induced long-range symmetrical pattern in the treated NPG as compared to control that led to increase in crystallinity.

The crystallite size was calculated using Scherrer formula (crystallite size=kλ/b cos θ) and the result are presented in Figure 2. The control NPG showed crystallite size 100.16 nm and that was decreased in treated NPG (78.15 nm). The result showed 21.97% decrease in crystallite size in treated NPG as compared to control sample. Mahmoud et al. reported that lattice strain induced by mechanical milling may causes significant reduction in crystallite size [28]. Hence, it is assumed here that biofield treatment may generate internal strain in the treated NPG molecules that caused decrease in crystallite size. Previously, our research group reported that biofield treatment had substantially reduced the crystallite size of vanadium pentoxide powders. It was proposed that internal strains made dislocations to move on the slip planes and intersecting slip planes built in stress concentration to such an extent causing the crystal to fracture at the sub boundaries [16]. Based on this, it is assumed that lattice strain might cause substantial reduction in crystallite size of NPG with respect to control.

DSC study

DSC thermogram of control and treated NPG are shown in Figure 3. The DSC thermogram of control NPG showed a sharp endothermic inflexion at 131.74°C that was due to melting temperature of the control NG. However, the treated NPG showed a slight shift in endothermic inflexion and it was observed at 132.59°C. This was due to melting of the treated NG. It was reported that melting temperature of a sample

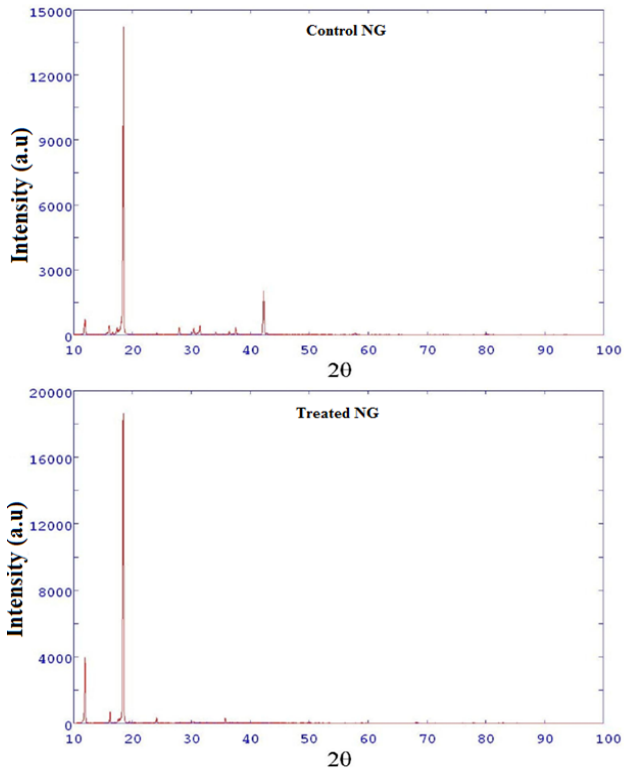

Figure 1: XRD diffractogram of control and treated neopentyl glycol (NPG).

depends on thermal vibration and kinetic energy of the atoms. The ΔH was calculated from DSC thermograms and the data are presented in Table 1. The ΔH of control NPG was 14.91 J/g; however, it was not significantly changed in treated NPG (13.99 J/g). It was previously reported that polyalcohols are heterogeneous at lower temperature but they become homogeneous face centered cubic crystals that have high symmetry and absorb energy when temperature rise to their own solid-solid phase transition temperatures [29]. Hence, it is assumed that biofield treatment may cause symmetrical crystal arrangement in treated NPG atoms that may lead to absorption of latent heat of energy.

TGA study

TGA was used to get the information about the thermal stability of control and treated NG. TGA thermogram, of control and treated NPG are presented in Figure 4. TGA of control NPG showed thermal degradation at around 135°C and the degradation terminated at around 195°C. During this thermal process the control NPG lost 55.66% of its sample weight. However, the treated NPG showed two step thermal degradation pattern. The first degradation step started at around 146°C and terminated at approximately 185°C. During this thermal step the treated sample lost 44.81% of its weight. The second thermal degradation started at around 200°C and terminated at approximately 228°C. During this step the treated NPG lost 12.86% of its weight. The comparative evaluation of weight loss during first step thermal degradation showed less percent of weight loss in treated NPG with respect to control that may be inferred as high thermal stability of the sample.

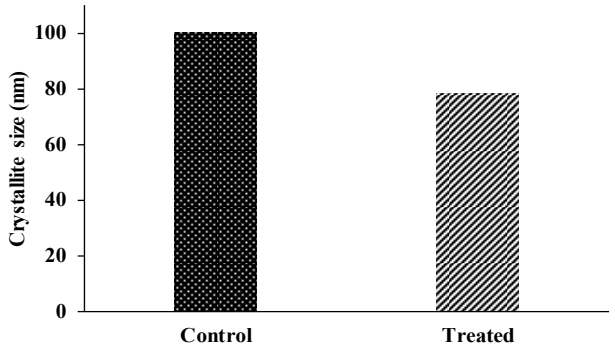

Figure 2: Crystallite size (nm) of control and treated neopentyl glycol (NPG).

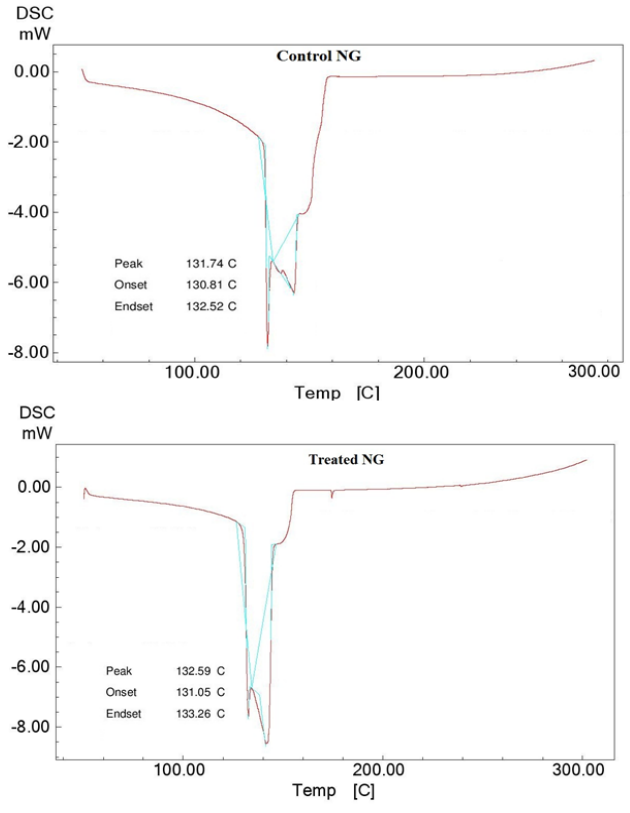

Figure 3: DSC thermogram of control and treated neopentyl glycol (NPG).

Parameter	Control	Treated
Latent heat of fusion ΔH (J/g)	14.91	13.99
Melting temperature (°C)	131.74	132.59
T_{max} (°C)	159.72	213.53
Weight loss (%)	56.55	44.81

Table 1: Thermal analysis data of control and treated neopentyl glycol (NPG).

DTA thermogram of control NPG showed two endothermic peaks; former peak was due to melting temperature (around 133°C) and later endothermic peak (172.66°C) was due to volatilization of the sample. However, the treated NPG also showed two endothermic peaks at 130.71°C and 170.51°C. The first endothermic peak was due to melting and second peak was due to volatilization of the sample.

Derivative thermogram (DTG) of control and treated NPG are shown in Figure 4. The control NPG showed maximum thermal decomposition temperature (T_{max}) at 159.72°C; however, it was minimally increased to 160.40°C in treated NPG sample. The increase in T_{max} of treated NG and decrease in weight loss corroborated its high thermal stability with respect to control sample. It is presumed that biofield treatment may act as a cross linker in NPG molecules that led to enhanced thermal stability. Sharma et al. reported that good thermal stability, cheap and wide availability of organic compounds allows them to be used as PCMs [1]. Hence, the high thermal stability of the treated NPG may be advantageous for its applications as PCMs.

FT-IR spectroscopy

FT-IR spectra of control and treated NPG are presented in Figure 5. The control NPG showed broad stretching vibrational peaks at 3288 cm^{-1} which was due to characteristic -OH group. Other peak were observed at 2956 cm^{-1}, was due to –CH stretching and 1475, 1356 cm^{-1} peaks were mainly due to -CH bending vibration peaks. The FT-IR spectrum of control NPG showed peaks at 1276 cm^{-1} which was due to C-O-H stretching vibration.

FT-IR spectrum of treated NG (T1) showed vibration peaks for –OH, and -CH stretching at 3288 and 2956 cm^{-1} respectively. Vibration peaks at 1475 and 1356 cm^{-1} were appeared due to –CH bending in the T1 sample. FT-IR peak for C-O-H stretching was observed at 1276 cm^{-1}.

Likewise, the treated NPG (T2) showed peaks at 3265 cm^{-1} which was mainly due –OH stretching vibration of the sample. The –CH stretching and bending vibrations were observed at 2962, 1475 and 1356 cm^{-1}. Vibrations peaks for C-O-H were observed at 1276 cm^{-1}. Overall, the FT-IR results showed no significant change in bond strength, force constant and dipole moment in treated NPG with respect to control.

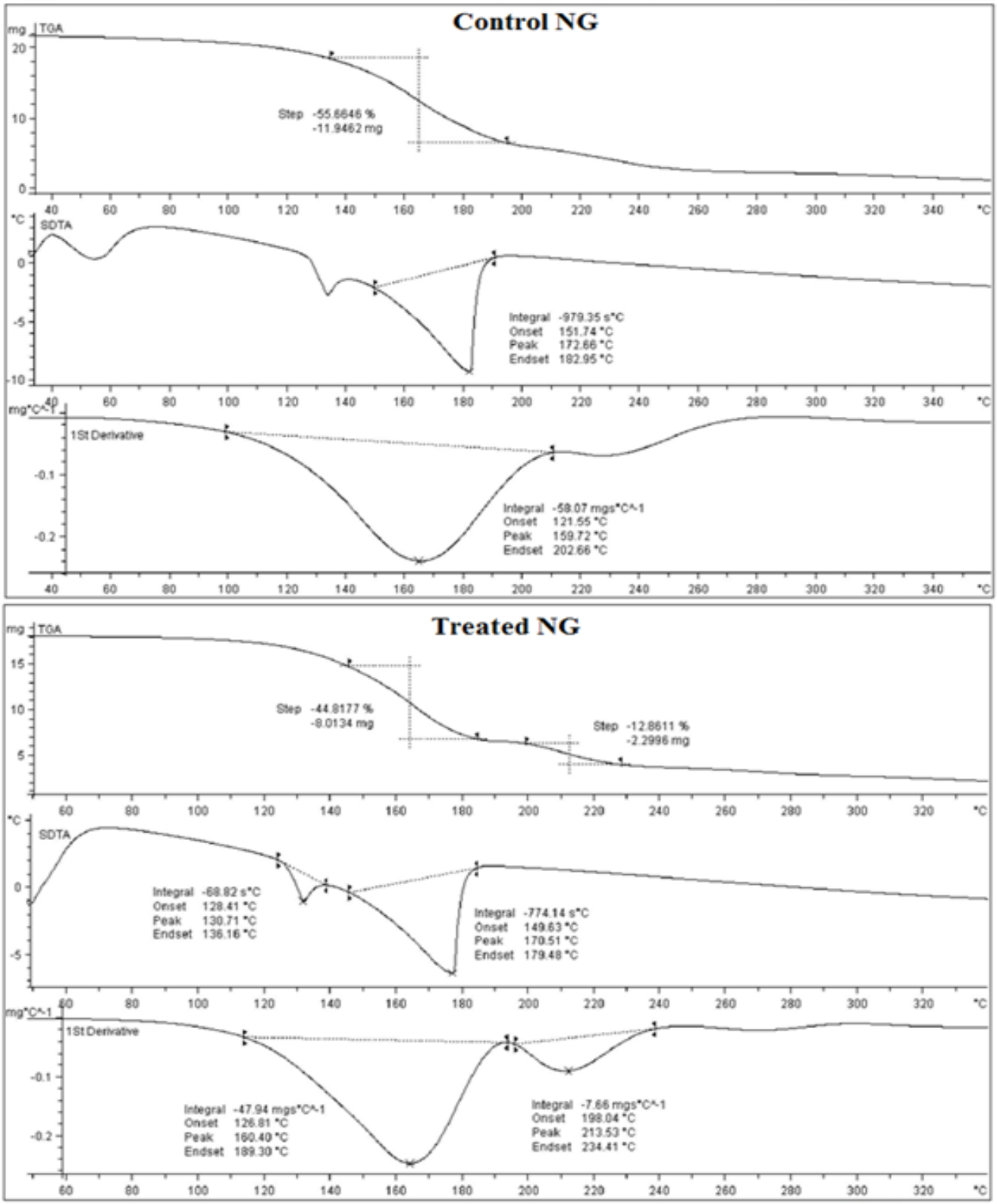

Figure 4: TGA thermogram of control and treated neopentyl glycol (NPG).

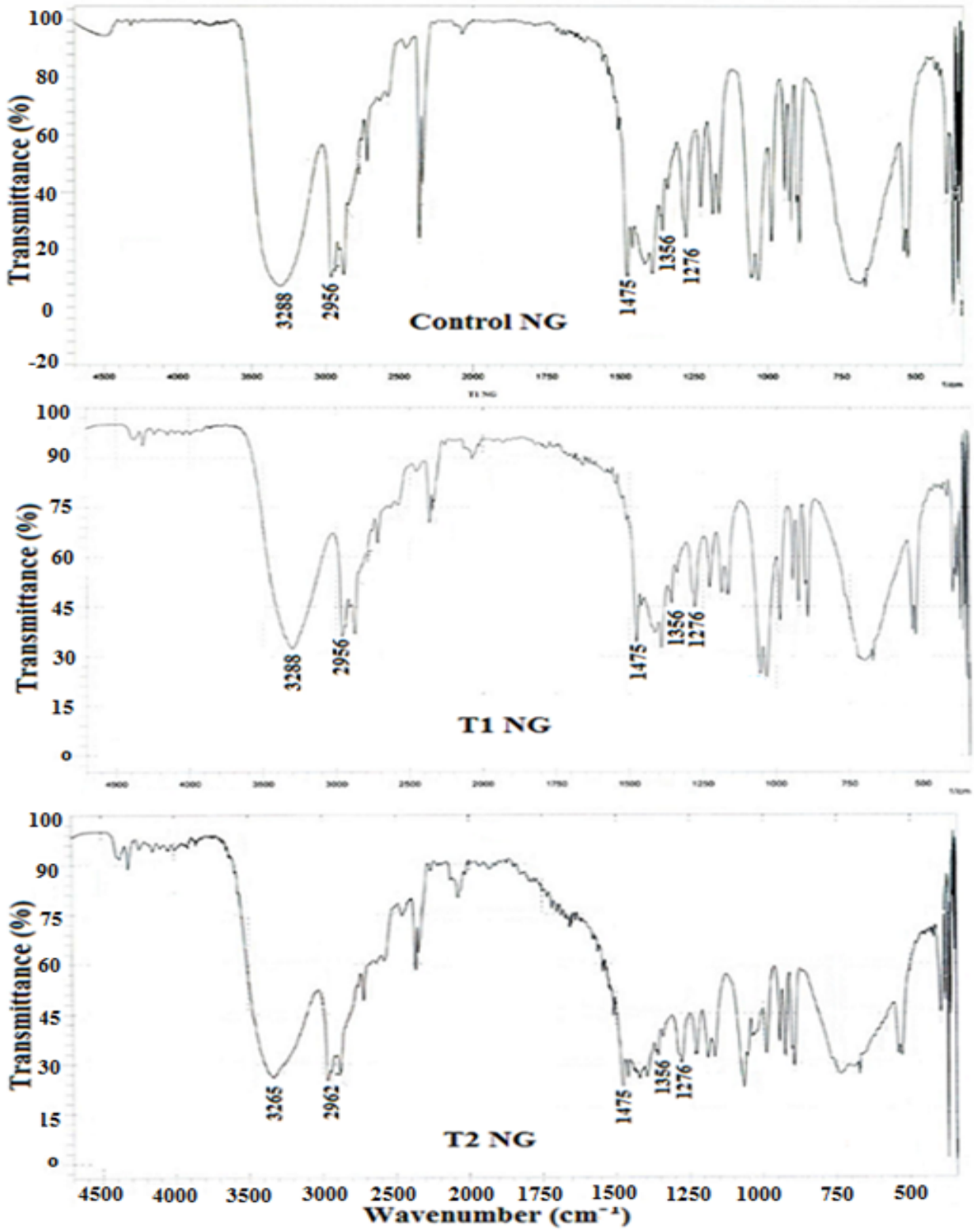

Figure 5: FT-IR spectra of control and treated (T1 and T2) neopentyl glycol (NPG).

Conclusions

In the present work biofield treatment has significantly affected the physical and thermal properties of the NG. XRD study revealed the increase in intensity of XRD peaks with respect to control. However, significant decrease in crystallite size of treated NPG with respect to control was observed. DSC analysis showed minimal change in melting temperature of treated NPG with respect to control sample. Moreover, decrease in weight loss of treated NPG was noticed as compared to control. Additionally, the T_{max} was minimally increased in treated NPG as compared to control that corroborated the thermal stability of the sample. FT-IR spectroscopic results of treated NPG showed no structural changes with respect to control. The stable melting temperature and appreciable thermal stability showed that the treated NPG could be a potential candidate for fabrication of PCMs for thermal energy storage applications.

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