

Characterization of Physical, Thermal and Spectral Properties of Biofield Treated 2,6-Dichlorophenol

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Abstract: 2,6-Dichlorophenol (2,6-DCP) is a compound used for the synthesis of chemicals and pharmaceutical agents. The present work is intended to evaluate the impact of Mr. Trivedi's biofield energy treatment on physical, thermal and spectral properties of the 2,6-DCP. The control and treated 2,6-DCP were characterized by various analytical techniques such as X-ray diffraction (XRD), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), Fourier transform infrared (FT-IR) spectroscopy, and ultra violet-visible spectroscopy (UV-vis) analysis. The XRD results showed the increase in crystallite size of treated sample by 28.94% as compared to the control sample. However, the intensity of the XRD peaks of treated 2,6-DCP were diminished as compared to the control sample. The DTA analysis showed a slight increase in melting temperature of the treated sample. Although, the latent heat of fusion of the treated 2,6-DCP was changed substantially by 28% with respect to the control sample. The maximum thermal decomposition temperature (T_{max}) of the treated 2,6-DCP was decreased slightly in comparison with the control. The FT-IR analysis showed a shift in C=C stretching peak from 1464→1473 cm^{-1} in the treated sample as compared to the control sample. However, the UV-vis analysis showed no changes in absorption peaks of treated 2,6-DCP with respect to the control sample. Overall, the result showed a significant effect of biofield energy treatment on the physical, thermal and spectral properties of 2,6-DCP. It is assumed that increase in crystallite size and melting temperature of the biofield energy treated 2,6-DCP could alleviate its reaction rate that might be a good prospect for the synthesis of pharmaceutical compounds.

Keywords: Biofield Energy Treatment, X-ray Diffraction, Thermal Analysis, Fourier Transform Infrared Spectroscopy, Ultra Violet-Visible Spectroscopy

1. Introduction

Phenol derivatives are commonly used in the pharmaceuticals, wood preservatives, rubber chemicals, dyes, pigments, explosives and industrial solvents [1]. Chlorophenols are known as the organochlorides of phenol that contains one or more covalently bonded chlorine atoms. These compounds are produced by the electrophilic halogenation of phenol with chlorine. Chlorophenols are commonly used as pesticides, herbicides, and disinfectants [2]. 2,4-Dichlorophenol was used as an intermediate for the synthesis of Bithionol, which is an anthelmintic drug of choice for treating human infected with *Fasciola hepatica*. It is used as an alternative drug for treating pulmonary and

cerebral paragonimiasis [3]. 2,6-Dichlorophenol (2,6-DCP) is a compound used as a sex pheromone of the tropical horse tick *Anocentor nitens* belongs to Ixodidae family [4]. Additionally, an 2,6-DCP indophenol is use as a redox dye which can be used to measure the rate of photosynthesis [5]. Cabello *et al.* reported that 2,6-DCP indophenol may serve as pro-oxidant chemotherapeutic targeting human cancer cells in an animal model of human melanoma. This compound induces cancer cell death by depleting the intracellular glutathione and upregulation of oxidative stress [6]. 2,6-DCP is also used for synthesis of pharmaceutical intermediate compounds [7].

Pharmaceutical stability is an important factor that governs the therapeutic efficacy and toxicity of the medications.

Based on Food and Drug Administration (FDA) regulations, the drug companies should determine a time limit to which they can assure the full potency and stability of the medications [8]. Thus, efficacious drugs with adequate shelf life are essential for their successful medical applications. Moreover, the chemical and physical stability of the pharmaceutical compounds are more desired quality attributes that directly affect its safety, efficacy, and shelf life [9]. Hence, some alternate approach should be used to improve the physicochemical properties of these compounds. Biofield energy was recently used as a method for modification of chemical, and thermal properties of various metals [10], organic compound [11], organic product [12], and pharmaceutical drugs [13]. Therefore, authors have planned to investigate the influence of biofield energy treatment on the physical, thermal and spectral properties of 2,6-DCP.

The National Centre for Complementary and Alternative Medicine (NCCAM), which is an integral part of the prestigious National Institute of Health (NIH), allows the use of Complementary and Alternative Medicine (CAM) therapies as an alternative in the healthcare field. About 36% of US citizens regularly use some form of CAM [14], in their daily activities. CAM embraces numerous energy-healing therapies; biofield therapy is one of the energy medicines used worldwide to alleviate overall human health.

Biofield therapy is known as a treatment modality that confers a change in people's health and well-being by interacting with their biofield [15]. The most commonly used biofield therapies are Reiki, therapeutic touch and Qi gong that are performed by the experts. Biofield energy healing is a healing therapy that works on the quantum level, and addresses physical, mental, emotional and spiritual imbalances simultaneously [15]. Moreover, the health of a human being also depends on the balance of the bioenergetics fields. It is believed that during the diseased condition this bioenergetics field is depleted [16]. Additionally, this biofield energy can be manipulated by the experts who are well versed in energy healing practice [17]. Therefore, it is suggested that human beings have the ability to harness the energy from the surrounding environment/Universe and can transmit into any object (living or non-living) around the Globe. The object(s) always receive the energy and responding in a useful manner that is called biofield energy.

Mr. Trivedi is known to transform the characteristics in various research fields such as biotechnology [18], microbiology [19] and agriculture [20]. This biofield energy treatment is also known as The Trivedi Effect®. Hence, by capitalizing on the unique biofield energy treatment and pharmaceutical properties of 2,6-DCP, this research work was perused to investigate the impact of biofield energy treatment on the physical, thermal and spectral properties of this compound. The control and treated samples were analyzed using various analytical techniques such as X-ray diffraction (XRD), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), Fourier transform infrared (FT-IR) spectroscopy, and ultra violet-visible

spectroscopy (UV-vis) analysis.

2. Materials and Methods

2,6-DCP was procured from S D Fine Chemicals Pvt. Limited, India. The sample was divided into two parts; one was kept as the control sample while the other was subjected to Mr. Trivedi's unique biofield energy treatment and coded as treated sample. The treated sample was in sealed pack and handed over to Mr. Trivedi for biofield energy treatment under laboratory condition. Mr. Trivedi gave the energy treatment through his unique energy transmission process to the treated samples without touching it.

2.1. X-ray Diffraction (XRD) Study

XRD analysis of control and treated 2,6-DCP was evaluated using X-ray diffractometer system, Phillips, Holland PW 1710 which consist of a copper anode with nickel filter. XRD system had a radiation of wavelength 1.54056 Å. The average crystallite size (G) was computed 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 ($=0.94$). Percentage change in average 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 denoted as crystallite size of control and treated powder samples respectively.

2.2. Differential Scanning Calorimetry (DSC)

The control and treated 2,6-DCP samples were analyzed using Pyris-6 Perkin Elmer DSC at a heating rate of 10°C/min and the air was purged at a flow rate of 5 mL/min. The predetermined amount of sample was kept in an aluminum pan and closed with a lid. A reference sample was prepared using a blank aluminum pan. The percentage change in latent heat of fusion was calculated using following equations:

$$\begin{aligned} \% \text{ Change in Latent heat of fusion} \\ = [\Delta H_{\text{Treated}} - \Delta H_{\text{Control}}] / \Delta H_{\text{Control}} \times 100 \end{aligned} \quad (1)$$

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

2.3. Thermogravimetric Analysis-Differential Thermal Analysis (TGA-DTA)

A Mettler Toledo simultaneous TGA and differential thermal analyzer (DTA) was used to investigate the thermal stability of control and treated 2,6-DCP samples. The heating rate was 5°C/min and the samples were heated in the range of room temperature to 400°C under air atmosphere.

2.4. FT-IR Spectroscopy

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

2.5. UV-Vis Spectroscopic Analysis

A Shimadzu UV-2400 PC series spectrophotometer with 1 cm quartz cell and a slit width of 2.0 nm was used to obtain the UV spectra of the control and treated 2,6-DCP samples. The spectroscopic analysis was carried out using wavelength in the range of 200-400 nm and methanol was used as a solvent. The biofield energy treated sample was divided in two parts T1 and T2 for the UV-Vis spectroscopic analysis.

3. Results and Discussions

3.1. XRD Study

XRD is a non-destructive technique that is used to evaluate the crystalline nature of the materials. The XRD diffractogram of control and treated 2,6-DCP are depicted in

Figure 1. The XRD diffractogram of the control and treated 2,6-DCP samples exhibited intense peaks that indicated the crystalline nature of the samples. The XRD diffractogram of control 2,6-DCP showed well defined intense peaks at Bragg's angle (2θ) equal to 15.69°, 17.37°, 22.17° and 27.97°. However, the treated 2,6-DCP compound showed the presence of intense XRD peak at 2θ equal to 15.48°. The comparative evaluation of the control and treated 2,6-DCP samples showed shifting and increase in the intensity from Bragg's angle (2θ) equal to 15.69°→15.48° in the treated sample as compared to control sample. It was reported previously that if any crystallite in the sample are strained (compressed) by the same amount this may result in a shift in XRD diffraction peaks [21]. Hence, it is assumed that biofield energy treatment might cause homogeneous strain that induced a shift in the XRD peak. Nevertheless, the other XRD peaks originally present at 17.37°, 22.17° and 27.97° in the control sample were disappeared or diminished in the treated sample. This may be correlated to decrease in crystallinity of the treated sample as compared to the control. Additionally, the change in crystal morphology on biofield treated sample might cause changes in the relative intensity of the XRD peaks with respect to control [22].

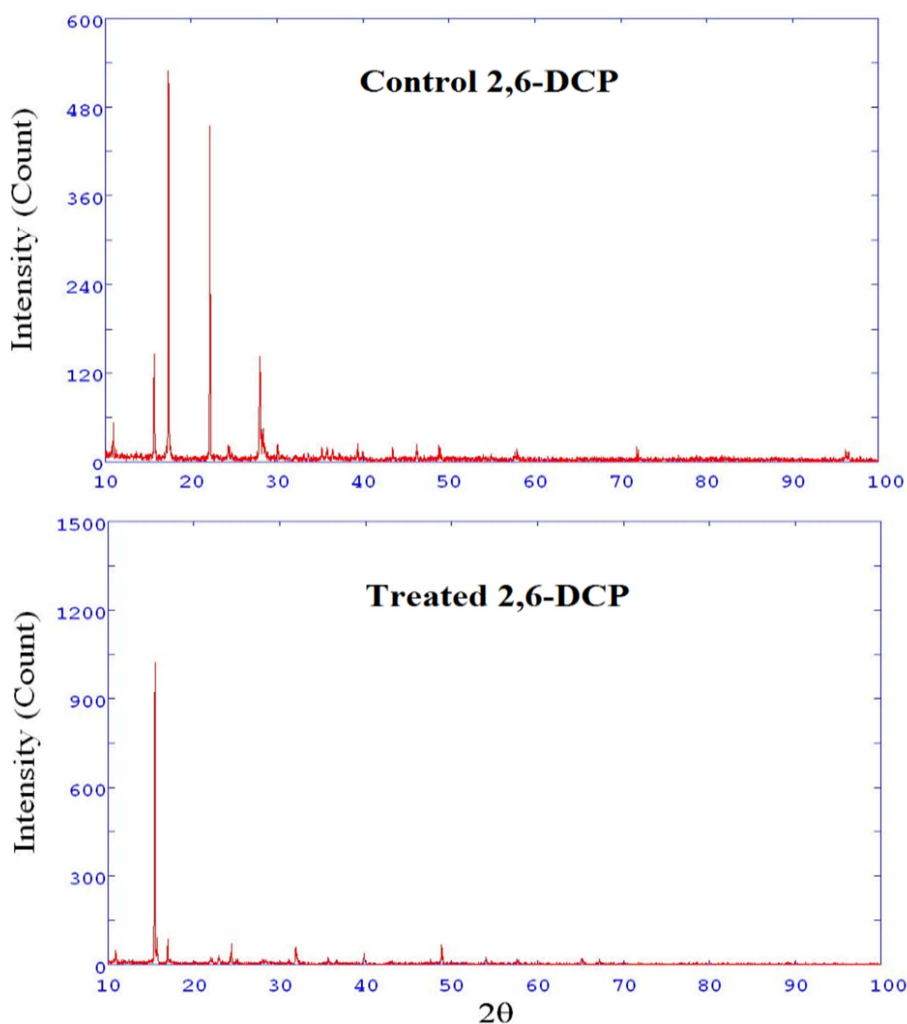


Fig. 1. XRD diffractograms of control and treated 2,6-dichlorophenol.

The crystallite size of control and treated 2,6-DCP were calculated using Scherrer formula and results are presented in Figure 2. The crystallite size of control 2,6-DCP was 80.35 nm and after biofield energy treatment it was increased up to 103.62 nm. The result suggested 28.94% increase in crystallite size of treated 2,6-DCP with respect to the control sample. It was reported that the structural defects such as interstitials, vacancies, dislocations, and layer faults cause inhomogeneous strain within the crystallite. Lalitha *et al.* [23] and El-kadry *et al.* [24] reported that a decrease in internal micro-strain in materials causes an increase in the crystallite size. Additionally, Chen *et al.* elaborated that decrease in micro-strain leads to a reduction in inter-planar spacing and this minimizes the stacking fault probability in the materials [25]. Hence, it is assumed here that biofield energy treatment might cause a decrease in internal micro-strain and this lead to a decrease in the inter-planar spacing and resultant increase in the crystallite size. It was reported previously that rate of a chemical reaction could be enhanced by elevation in crystallite size of the compounds [26]. Since, 2,6-DCP is used as intermediate for the synthesis of compounds hence, increase in crystallite size might improve its reaction rate and reaction yield.

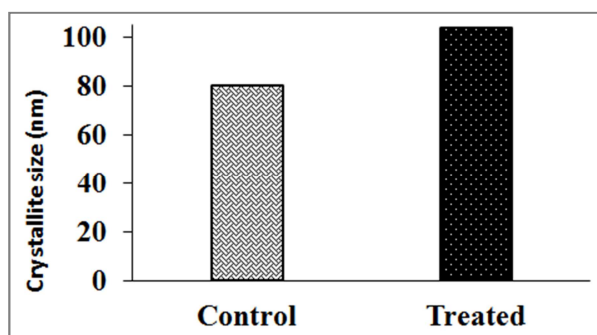


Fig. 2. Crystallite size of control and treated 2,6-dichlorophenol.

3.2. DSC Characterization

DSC is a thermal analysis technique used for the evaluation of melting temperature, glass transition and latent heat of fusion of the materials. DSC thermograms of the control and treated samples are presented in Figure 3. DSC thermogram of the control 2,6-DCP showed a sharp endothermic peak at 67.68°C due to melting temperature of the sample. However, the treated 2,6-DCP sample showed no change in melting temperature (67.30°C) as compared to the control.

The latent heat of fusion of control and treated 2,6-DCP were recorded from the DSC thermograms and data are depicted in Table 1. The latent heat of fusion of control 2,6-DCP was 136.84 J/g and after treatment it was decreased to 98.53 J/g. The result suggested that the latent heat of fusion of treated sample was decreased by 28% as compared to the control. The latent heat of fusion is the energy absorbed during phase change of material from solid to liquid. It is assumed that biofield treatment might alter the energy stored in the treated 2,6-DCP sample that lead to a reduction in the

latent heat of fusion of the sample. Moreover, it is hypothesized that the treated sample might be present in the high-energy state that led to a reduction in latent heat of fusion. Recently, from our research group it was reported that biofield energy treatment effectively altered the latent heat of fusion of thymol and menthol [27].

3.3. TGA Analysis

TGA thermograms of control and treated 2,6-DCP are presented in Figure 4. The TGA thermogram of the control 2,6-DCP started to degrade thermally at 130°C, and it terminated at 172°C. The sample lost 48.42% weight during this process. However, the TGA thermogram of treated 2,6-DCP showed thermal degradation at 130°C, and this step terminated at around 170°C. During this process, the sample lost 51.52% of its initial weight.

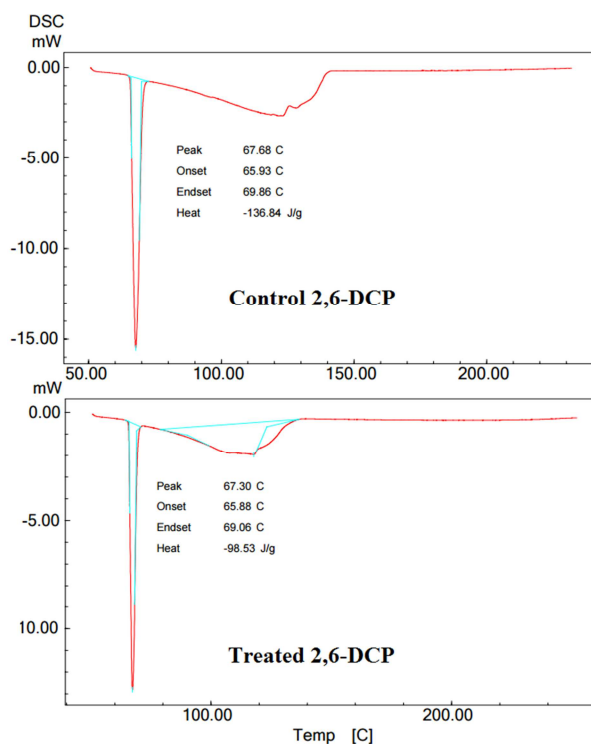


Fig. 3. DSC thermograms of control and treated 2,6-dichlorophenol.

The DTA thermogram of the control and treated 2,6-DCP are presented in Figure 4. The DTA thermogram of control 2,6-DCP showed two endothermic peaks at 68.22°C and 156.24°C. The former peak was mainly due to melting temperature of the compound. While the later peak was due to thermal decomposition of the compound chains. The treated 2,6-DCP also showed two endothermic peaks at 69.08°C and 155.99°C. The first endothermic peak was due to melting temperature and second was due to the thermal decomposition. This showed a slight increase in melting temperature of the treated sample as compared to the control. This was probably due to biofield energy treatment that might increase the intermolecular interaction in the treated sample and resultant increase in melting temperature. It was

reported that chlorophenol derivatives can form strong hydrogen bond complexes with other molecules [28]. Similarly, 2,6-DCP compound also have a stronger tendency to intermolecular hydrogen bond formation [29]. Therefore, it is assumed that biofield energy might be absorbed in the treated 2,6-DCP that leads to the formation of hydrogen bond which ultimately increases the melting temperature.

The Derivative thermogravimetry (DTG) thermogram of control and treated sample are shown in Figure 4. The DTG thermogram of the control sample showed maximum thermal decomposition temperature (T_{max}) at 147.15°C and it almost remained unchanged in the treated sample (146.41°C). This suggested no significant change in T_{max} of treated 2,6-DCP after the biofield treatment.

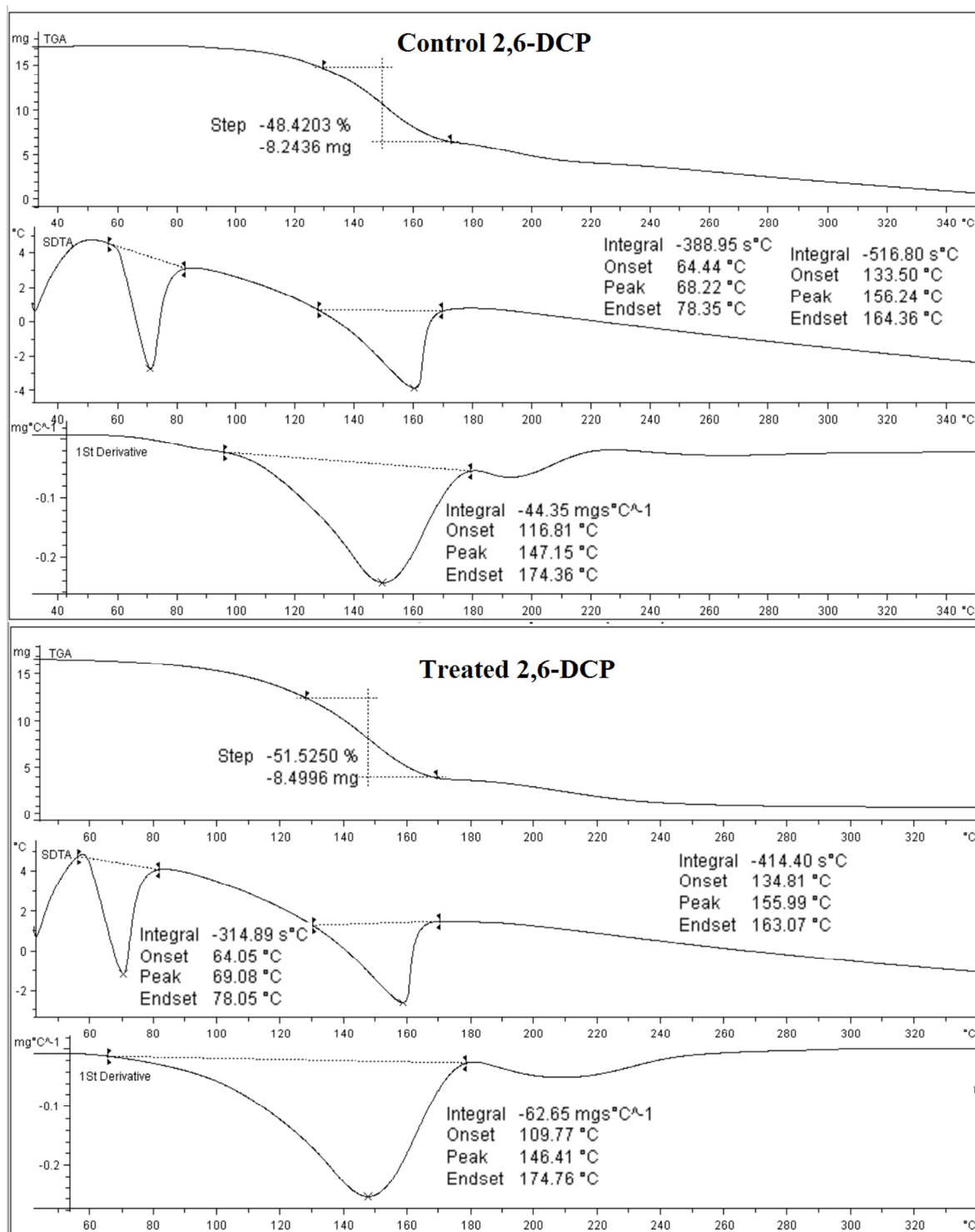


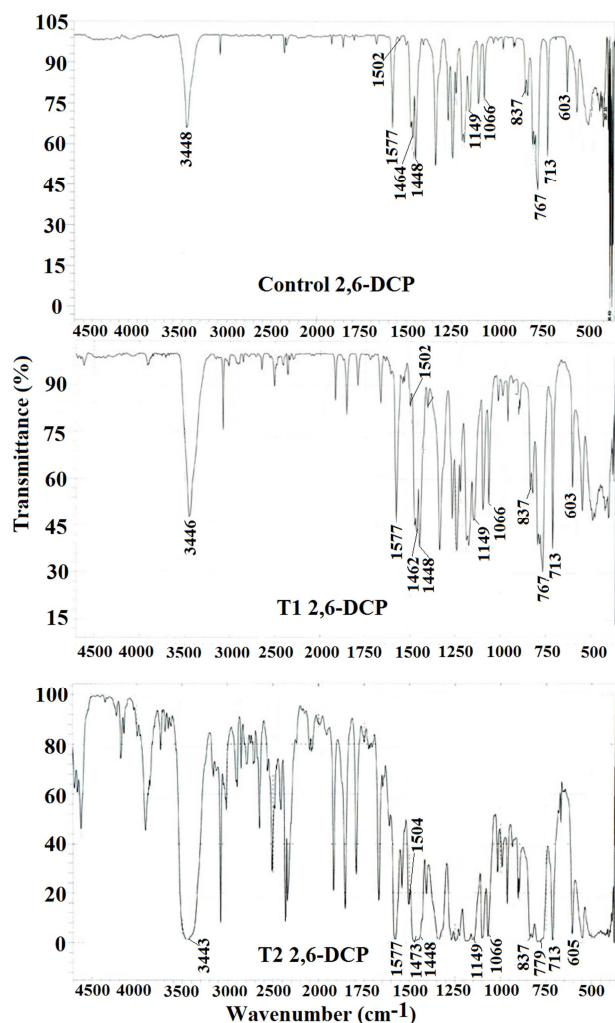
Fig. 4. TGA thermograms of control and treated 2,6-dichlorophenol.

Table 1. Thermal analysis data of control and treated 2,6-dichlorophenol.

Parameter	Control	Treated
Latent heat of fusion ΔH (J/g)	136.84	98.53
Melting temperature ($^{\circ}\text{C}$)	67.68	67.30
T_{max} ($^{\circ}\text{C}$)	147.15	146.41
Weight loss (%)	48.42	51.52

T_{max} : Maximum thermal decomposition temperature

3.4. FT-IR Spectroscopy

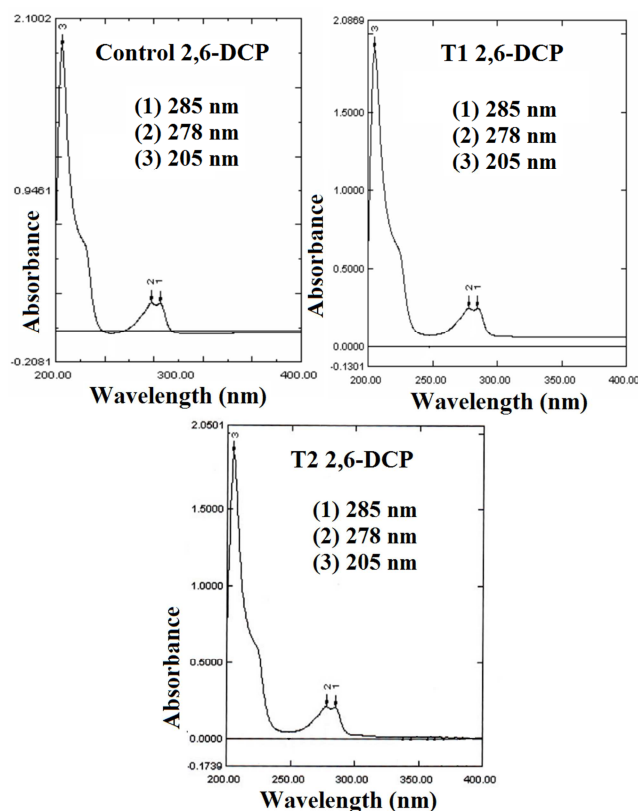
**Fig. 5.** FT-IR spectra of control and treated 2,6-dichlorophenol (T1 and T2).

The FT-IR spectra of control and treated 2,6-DCP are depicted in Figure 5. The FT-IR spectrum of the control sample showed a broad peak at 3448 cm^{-1} that was due to O-H stretch of the phenol group. Whereas, in case of treated samples (T1 and T2), it appeared at 3446 and 3443 cm^{-1} , respectively. The C=C stretching peak was observed in the region of 1448 – 1577 cm^{-1} in the control, treated samples (T1 and T2) samples. The characteristic C-Cl stretching vibration peak was appeared at 837 cm^{-1} in all the control and treated (T1 and T2) 2,6-DCP samples. The C-H out of plane bending peaks were observed in the region of 603 – 767 cm^{-1} in the control and T1 sample. However, the T2 sample showed in

the region of 605 – 779 cm^{-1} . The C-H in plane bending peaks were appeared at 1149 cm^{-1} in the control and treated samples (T1 and T2). The C-O stretch was appeared at 1066 cm^{-1} in all the control and treated 2,6-DCP samples. The FT-IR results were well supported by the literature [30]. Overall, the result showed an upward shift in C=C stretching peak from $1464 \rightarrow 1473\text{ cm}^{-1}$ in the treated sample as compared to the control. Therefore, it is presumed that biofield energy treatment might increase the dipole moment of C=C bond as compared to the control sample [31].

3.5. UV-visible Spectroscopy

The UV-visible spectroscopy was used to investigate the chemical changes in the 2,6-DCP after biofield treatment. The UV spectra of control and treated 2,6-DCP samples are shown in Figure 6. The UV spectrum of control sample showed an absorbance peaks at 285, 278 and 205 nm. Nevertheless, the treated sample showed no changes in absorption peaks which were evidenced at 285, 278 and 205 nm in the treated 2,6-DCP (T1 and T2) samples, respectively [32]. Overall, the UV results showed no changes in absorption peaks in biofield energy treated samples as compared to the control. Hence, it is suggested that the biofield treatment did not disturb the energy gap between highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO) [31] in the treated samples, and it was found similar to the control sample.

**Fig. 6.** UV-vis spectra of control and treated 2,6-dichlorophenol (T1 and T2).

4. Conclusion

In summary, the XRD results revealed a decrease in intensity and increase in crystallite size of the treated 2,6-DCP as compared to the control sample. It is hypothesized that biofield treatment could have provided the energy that caused a reduction in dislocation density and increase in crystallite size. The DTA result showed a slight increase in melting temperature of the treated 2,6-DCP as compared to the control. However, TGA and DTG analysis showed no changes in onset temperature and T_{max} of the treated sample. The FT-IR analysis showed alterations in wavenumber of C=C group stretching of the treated samples as compared to the control sample. It was presumed that it might be due to the increase in dipole moment of the C=C bond as compared to the control sample. Overall, the result showed the impact of biofield energy treatment on physical, thermal and spectral properties of 2,6-DCP. The increase in crystallite size and minimal increase in melting temperature of the biofield energy treated 2,6-DCP might improve its reaction rate thus, it could be utilized as intermediate for the synthesis of pharmaceutical compounds.

Abbreviations

XRD: X-ray diffraction;
DSC: Differential scanning calorimetry;
TGA: Thermogravimetric analysis;
FT-IR: Fourier transform infrared;
UV-vis: Ultra violet-visible spectroscopy;
CAM: complementary and alternative medicine

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