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# Physicochemical and Spectroscopic Characteristics of Biofield Treated *p*-Chlorobenzophenone

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**Abstract:** *p*-Chlorobenzophenone (*p*-CBP) is the important chemical intermediate used for the synthesis of several pharmaceutical drugs like fenofibrate, cetirizine, alprazolam, and benzodiazepine. The aim of this study was set to evaluate the impact of biofield energy treatment on physicochemical and spectroscopic properties of *p*-CBP. The study was accomplished in two groups *i.e.* control and treated. The treated group was subjected to Mr. Trivedi's biofield energy treatment. Subsequently, the control and treated samples of *p*-CBP were analyzed using X-ray diffraction (XRD), particle size analyzer, surface area analyzer, differential scanning calorimetry (DSC), thermogravimetric analysis-derivative thermogravimetric analysis (TGA-DTG), Fourier transform infrared (FT-IR), and ultraviolet-visible (UV-Vis) spectroscopy. The XRD study exhibited the increase in average crystallite size (25.93%) as well as the intensity of XRD peaks of treated *p*-CBP, as compared to the control. The particle size analysis showed the reduction in particle size of fine particles ( $\leq 51.49 \mu\text{m}$ ) by 21.6% ( $d_{10}$ ), whereas, increase in particle size of large particles ( $\geq 433.59 \mu\text{m}$ ) by 12.82% ( $d_{90}$ ) and 17.71% ( $d_{99}$ ), respectively after biofield treatment, as compared to the control. The surface area analysis exhibited the surface area as  $0.7005 \text{ m}^2/\text{g}$  in control and  $0.7020 \text{ m}^2/\text{g}$  in treated sample of *p*-CBP. The DSC thermogram of treated *p*-CBP exhibited the slight decrease in melting temperature. However, the latent heat of fusion was significantly altered (24.90%) after biofield energy treatment as compared to the control. TGA analysis showed the weight loss by 57.36% in control and 58.51% in treated sample. In addition, the onset temperature of thermal degradation was also decreased by 6.32% after biofield energy treatment as compared to the control *p*-CBP. The FT-IR and UV spectroscopic study did not show the alteration in the wavenumber and wavelength, respectively in treated *p*-CBP as compared to the control. Altogether, the XRD, particle size and thermal analysis suggest that biofield energy treatment has significant impact on physical and thermal properties of treated *p*-CBP.

**Keywords:** *p*-Chlorobenzophenone, Biofield Treatment, X-ray Diffraction, Particle Size Analysis, Differential Scanning Calorimetry, Thermogravimetric Analysis

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## 1. Introduction

Benzophenones (diphenyl ketones) are the important compounds and refer to all types of substituted benzophenone. They are widely used in organic synthesis of several pharmaceutical drugs like anxiolytic, hypnotic and antihistaminic. Benzophenone is also used as the starting material for dyes, pesticides and natural products [1, 2]. It has rose-like odor, therefore used in the preparation of synthetic perfumes. Benzophenones are used as a photoinitiator of UV-curing applications in inks, optical

fibers, adhesive, coatings, and in printed circuit boards [3]. Photoinitiators are compounds, which break down into free radicals upon ultraviolet radiation exposure. The cosmetic grade benzophenone is used in sunscreen to reduce skin damage by blocking UV radiations *i.e.* UV-A (320-400 nm) and UV-B (290-320 nm) [4]. Benzophenones are also known to be pharmacologically active and reported as DNA photosensitizers [5]. Based on the importance of benzophenone as a chemical intermediate for organic synthesis of pharmaceutical drug. It is advantageous to find out the alternate approach that can enhance the

physicochemical and thermal properties of *p*-chlorobenzophenone (*p*-CBP). Recently, biofield energy treatment was reported to alter the physicochemical and thermal properties of several metals [6, 7] and ceramics [8, 9]; and spectroscopic properties of various pharmaceutical drugs like chloramphenicol, tetracycline, paracetamol, and piroxicam [10, 11].

The National Institute of Health/National Center for Complementary and Alternative Medicine (NIH/NCCAM) considered the biofield energy therapy (therapy) in subcategory of energy therapies (putative energy fields) [12, 13]. The biofield energy treatment has been used in healing process to reduce pain, anxiety and to promote the overall health of human being [14, 15]. According to the Maxwell JC, the every vibrant process in the human body has an electrical significance that generates magnetic field in the human [16]. This electromagnetic field of the human body is known as the biofield and energy associated with this field is termed as the biofield energy [17, 18]. Prakash *et al.* reported that various scientific instruments such as Kirlian photography, resonance field imaging (RFI) and polycontrast interference photography (PIP) can be extensively used to measure the biofield of human body [19]. Thus, the human has the ability to harness the energy from the environment or Universe and transmit this energy to any living or nonliving object on the Globe. The object(s) receive the energy and respond into useful way; this process is termed as biofield treatment. Mr. Trivedi's unique biofield energy is known as The Trivedi Effect<sup>®</sup>. Recently, the biofield energy treatment has been evaluated in several fields like biotechnology [20], microbiology [21, 22], material science [6-9], and agricultural science [23, 24].

Based on the published literature and outstanding impact of biofield energy treatment on various living and nonliving things, the present study was aimed to evaluate the impact of biofield energy treatment on physicochemical and spectroscopic properties of *p*-CBP using various analytical techniques.

## 2. Materials and Methods

### 2.1. Study Design

*p*-Chlorobenzophenone was procured from Sisco Research Laboratories, India. The study was carried out in two groups *i.e.* control and treatment. The control sample was remained as untreated; and treatment sample was handed over in sealed pack to Mr. Trivedi for biofield energy treatment under laboratory conditions. Mr. Trivedi rendered the biofield energy treatment through his unique energy transmission process *i.e.* thought transmission to the treatment group without touching the sample. After the biofield treatment, both the control and treated samples of *p*-CBP were analyzed using various analytical techniques like the X-ray diffractometry (XRD), particle size analyzer, surface area analyzer, differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), Fourier transform

infrared (FT-IR), and ultraviolet-visible (UV-Vis) spectroscopy.

### 2.2. XRD Study

XRD analysis of *p*-CBP was carried out on Phillips, Holland PW 1710 X-ray diffractometer with nickel filter and copper anode. X-ray wavelength used in XRD system was 1.54056 Å. The XRD diffractogram was obtained in the form of a chart of  $2\theta$  vs. intensity. The average crystallite size ( $G$ ) and percent change in average crystallite size of *p*-CBP were calculated using the following equations [25].

$$\text{Average crystallite size (G)} = k\lambda / (b\cos\theta) \quad 1$$

$$\begin{aligned} \text{Percent change in average crystallite size (G)} \\ = [(G_t - G_c) / G_c] \times 100 \quad 2 \end{aligned}$$

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

### 2.3. Particle size Analysis

The particle size of control and treated *p*-CBP was determined using laser particle size analyzer Sympatec HELOS-BF, with detection range of 0.1–875 μm. The particle size data were collected in the form of a chart of particle size vs. cumulative percentage. The particle sizes *i.e.*  $d_{10}$ ,  $d_{50}$ ,  $d_{90}$ , and  $d_{99}$  (size below which 10%, 50%, 90%, and 99% particles are present, respectively) were computed from the particle size distribution curve. The percentage change in particle size was calculated with the help of following equation.

$$\% \text{ change in particle size, } d_{10}$$

$$= \frac{[(d_{10})_{\text{Treated}} - (d_{10})_{\text{Control}}]}{(d_{10})_{\text{Control}}} \times 100 \quad 3$$

Where,  $(d_{10})_{\text{Control}}$  and  $(d_{10})_{\text{Treated}}$  are the particle size  $d_{10}$  of control and treated samples respectively. Accordingly, the percent changes in particle size *i.e.*  $d_{50}$ ,  $d_{90}$ , and  $d_{99}$  were calculated.

### 2.4. Surface Area Analysis

Surface area of control and treated *p*-CBP was measured using the Brunauer–Emmett–Teller (BET) surface area analyzer, Smart SORB 90. Percent change in surface area was calculated using following equation:

$$\% \text{ change in surface area} = \frac{[S_{\text{Treated}} - S_{\text{Control}}]}{S_{\text{Control}}} \times 100 \quad 4$$

Where,  $S_{\text{Control}}$  and  $S_{\text{Treated}}$  are the surface area of control and treated samples, respectively.

### 2.5. DSC Study

The control and treated samples of *p*-CBP were studied using a Pyris-6 Perkin Elmer differential scanning calorimeter on a heating rate of 10°C/min under air atmosphere with air flow rate of 5 mL/min. An empty pan

sealed with cover was used as a reference pan. The melting temperature ( $T_m$ ) and latent heat of fusion ( $\Delta H$ ) were obtained from the DSC curve.

## 2.6. TGA-DTG Analysis

The effect of biofield energy treatment on thermal properties of control and treated *p*-CBP were studied using Mettler Toledo simultaneous TGA-DTG. The samples were heated up to 400°C from room temperature at the heating rate of 5°C/min under air atmosphere. The onset temperature at which thermal degradation starts and percent change in temperature at which maximum weight loss occurs in sample were acquired from DTG thermogram.

## 2.7. Spectroscopic Studies

For the purpose of FT-IR and UV-Vis spectroscopic characterization, the treated sample was divided into two groups *i.e.* T1 and T2. Both treated groups were separately analyzed for their spectroscopic characteristics using FT-IR and UV-Vis spectroscopy and data were compared with the respective spectrum of control *p*-CBP sample.

### 2.7.1 FT-IR Spectroscopic Characterization

FT-IR spectra of control and treated samples of *p*-CBP were obtained from Shimadzu's Fourier transform infrared spectrometer (Japan) with the frequency range of 4000-500  $\text{cm}^{-1}$ . The analysis was accomplished to evaluate the impact of biofield energy treatment at atomic level like force constant, dipole moment, and bond strength in chemical structure [26].

### 2.7.2. UV-Vis Spectroscopic Analysis

UV spectra of control and treated samples of *p*-CBP were acquired from Shimadzu UV-2400 PC series spectrophotometer. Quartz cell with 1 cm and a slit width of 2.0 nm were used for analysis. The study was carried out at wavelength in the region of 200-400 nm. The UV spectra were analyzed to find out the effect of biofield energy treatment on the energy gap of highest occupied molecular orbital and lowest unoccupied molecular orbital (HOMO-LUMO gap) [26].

## 3. Results and Discussion

### 3.1. XRD Analysis

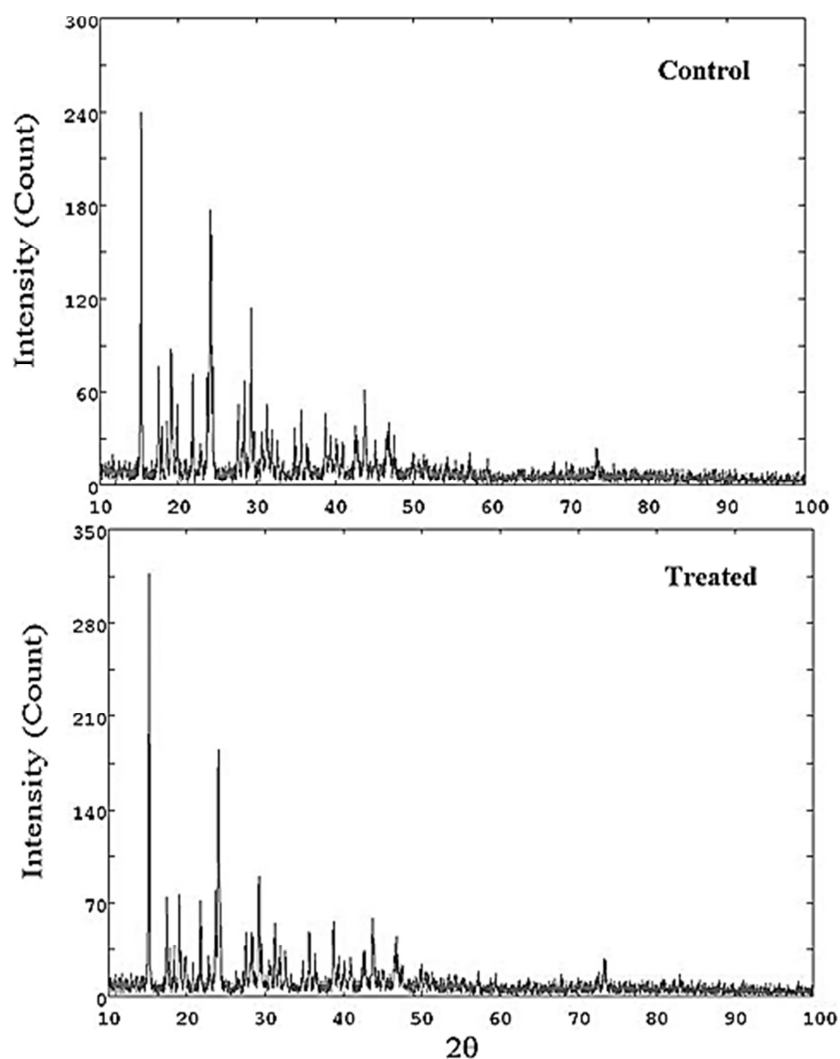


Fig. 1. XRD diffractograms of *p*-chlorobenzophenone.

XRD diffractograms of control and treated *p*-CBP are shown in Fig. 1. The control *p*-CBP exhibited the XRD peaks at  $2\theta$  equal to  $15.25^\circ$ ,  $17.47^\circ$ ,  $19.04^\circ$ ,  $21.82^\circ$ ,  $23.72^\circ$ ,  $24.08^\circ$ ,  $28.41^\circ$ , and  $29.27^\circ$ . However, the XRD diffractogram of treated *p*-CBP showed the XRD peaks at  $2\theta$  equal to  $15.22^\circ$ ,  $17.48^\circ$ ,  $19.04^\circ$ ,  $21.76^\circ$ ,  $23.66^\circ$ ,  $24.03^\circ$ ,  $29.21^\circ$ , and  $31.27^\circ$ , with increased intensity of XRD peaks as compared to the control. The sharp peaks in XRD diffractogram of both control and treated samples suggest the crystalline nature of *p*-CBP. The increase in intensity of XRD peaks in treated sample may be attributed to enhanced crystallinity as compared to the control. It is assumed that treated *p*-CBP molecules absorbed biofield energy that may lead to formation of long-range symmetrical crystalline pattern as compared to the control sample.

The average crystallite size was calculated using Scherrer formula and the results are shown in Fig. 2. The average crystallite size of control *p*-CBP was found as 83.18 nm that was increased to 104.75 nm in treated sample. The result showed about 25.93% increase in average crystallite size in treated sample as compared to the control.

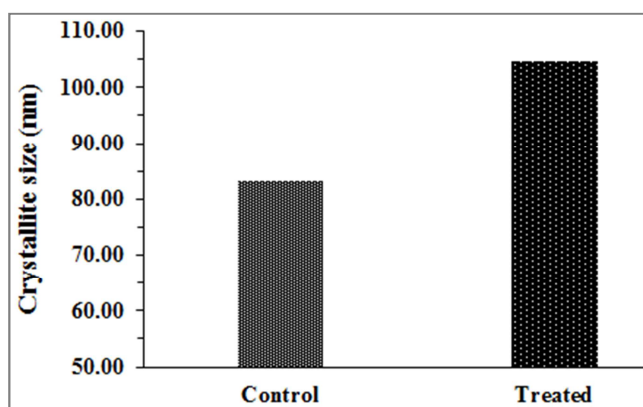


Fig. 2. Crystallite size of control and treated *p*-chlorobenzophenone.

The role of temperature on average crystallite size is well reported in the literature, which indicates that increase in temperature reduces the thermodynamically driven force. This leads to decrease in nuclear densities and thus increase in average crystallite size [27, 28]. Moreover, Gaber *et al.* described that elevation in processing temperature causes to decrease in dislocation density and increase in number of unit cell, which finally increased the average crystallite size [29]. Based on these, it is assumed that biofield energy treatment may provide the energy to *p*-CBP that causes decrease in dislocation density and increase in average crystallite size.

### 3.2. Particle Size Analysis

The particle size was determined in four groups *i.e.*  $d_{10}$ ,  $d_{50}$ ,  $d_{90}$ , and  $d_{99}$  (size below which 10%, 50%, 90%, and 99% particles are present, respectively) and result are presented in Fig. 3. The particle size result showed  $d_{10}$ ,  $d_{50}$ ,  $d_{90}$ , and  $d_{99}$  as 51.49, 160.15, 433.59, and 588.07  $\mu\text{m}$ , respectively in control sample, which were converted to 40.37, 157.66,

489.16, 692.19  $\mu\text{m}$ , respectively after biofield treatment. The results suggest that  $d_{10}$  and  $d_{50}$  particle sizes were decreased by 21.60% and 1.55% in treated *p*-CBP as compared to the control.

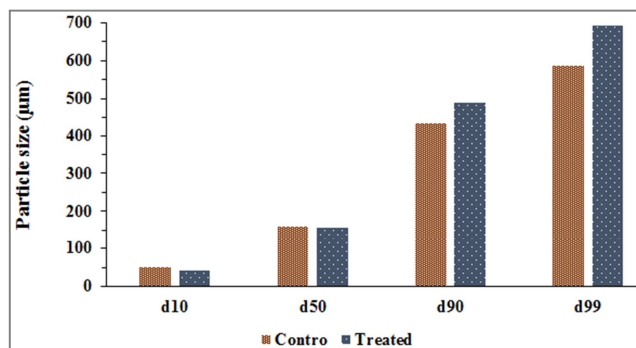


Fig. 3. Particle size analysis of control and treated *p*-chlorobenzophenone.

On the contrary, the  $d_{90}$  and  $d_{99}$  were found to increase up to 12.82% and 17.71%, in treated *p*-CBP respectively with respect to the control. The reduction of  $d_{10}$  and increase of  $d_{90}$  could be possible if fracturing and agglomeration took place simultaneously in treated *p*-CBP. Recently, our group reported the effect of biofield energy treatment on the particle size of manganese oxide [8]. It was described that finer particles get agglomerated after biofield energy treatment and lead to increase the percent of larger particle size. Thus, it is assumed that the energy, probably transferred through biofield treatment, might induce fracturing and agglomeration process in treated *p*-CBP, which resulted into alteration in particle sizes. Altogether, the result exhibited the alteration in the particle size of *p*-CBP after biofield treatment.

### 3.3. Surface Area Analysis

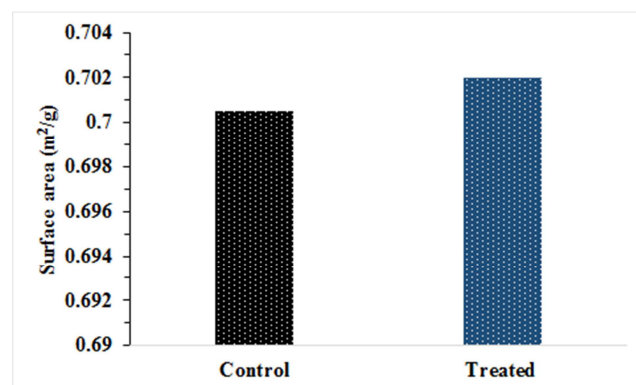


Fig. 4. Surface area analysis of control and treated *p*-chlorobenzophenone.

The surface areas of control and treated samples of *p*-CBP were determined using BET surface area analyzer and data are presented in Fig. 4. The control sample showed a surface area of  $0.7005 \text{ m}^2/\text{g}$ ; however, the treated sample showed a surface area of  $0.7020 \text{ m}^2/\text{g}$ . The result showed a slight increase in surface area (0.21%) in the treated *p*-CBP as compared to the control. The increase in surface area

might be correlated to particle size reduction in fine particle region due to high internal strain produced by biofield energy treatment [30]. The increase in surface area may lead to increase in solubility and reactivity of *p*-CBP as compared to the control.

### 3.4. DSC Analysis

DSC analysis was performed to determine the melting

temperature and latent heat of fusion ( $\Delta H$ ) of control and treated *p*-CBP. In solid substance, an ample amount of interaction force exists in atomic bonds that hold the atoms at their positions. The energy required to overcome the interaction force of phase change *i.e.* solid into liquid is known as latent heat of fusion. DSC thermogram (Fig. 5) of *p*-CBP showed the melting temperature at 77.57°C in control and 76.82°C in treated sample (Table 1).

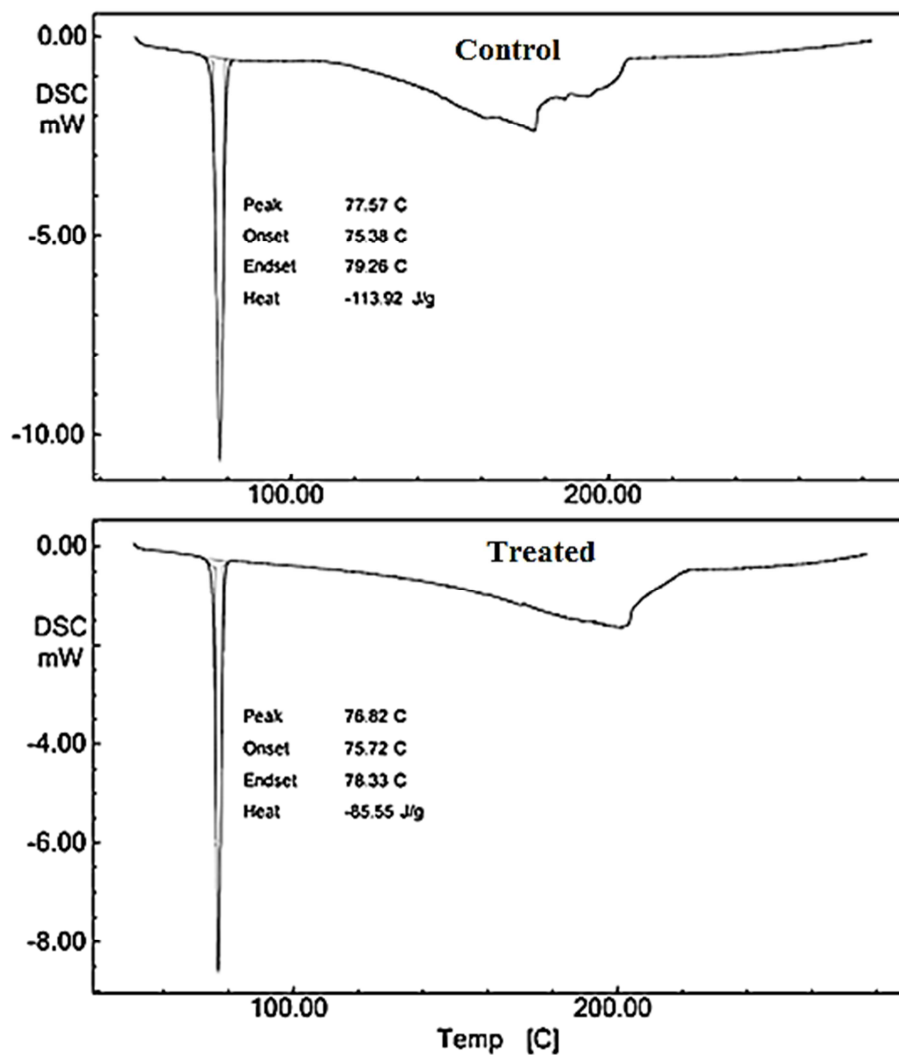


Fig. 5. DSC thermograms of control and treated *p*-chlorobenzophenone.

Table 1. Thermal analysis of control and treated samples of *p*-chlorobenzophenone.

Parameter	Control	Treated
Latent heat of fusion (J/g)	113.92	85.55
Melting point (°C)	77.57	76.82
Onset temperature (°C)	190	178
End-set temperature (°C)	230.5	238
T <sub>max</sub> (°C)	207.51	206.33

T<sub>max</sub>: temperature at maximum weight loss occurs

The result showed about 0.97% decrease in melting temperature in treated sample of *p*-CBP as compared to the control. The melting temperature of control *p*-CBP was well

supported by literature data [31]. DSC thermogram exhibited the  $\Delta H$  of 113.92 J/g in control sample and 85.55 J/g in treated sample of *p*-CBP. The result showed 24.90% decrease in  $\Delta H$  of treated sample as compared to the control. It is presumed that, biofield energy treatment probably supplied the energy to treated sample that is stored in the form of potential energy. Therefore, it required less energy during phase change due to the high-energy state of biofield treated samples. Previously, our group has reported that biofield energy treatment altered the value of  $\Delta H$  in lead and tin powders [6]. Therefore, it is assumed that biofield energy treatment might change the intermolecular interaction of treated *p*-CBP that may lead to decrease the  $\Delta H$ .

### 3.5. TGA-DTG Analysis

The TGA and DTG thermogram of control and treated samples of *p*-CBP are shown in Fig. 6 and data are reported in Table 1. TGA thermogram of control *p*-CBP showed the onset temperature around 190.0°C, while the end-set temperature was observed at 230.5°C with 57.36% weight loss. However, the treated *p*-CBP started losing weight around 178°C and the end-set was observed at 238°C with 58.52% weight loss (Fig. 6). The result showed the decrease in onset temperature by 6.32% and increase in end-set

temperature by 3.25% in treated sample of *p*-CBP as compared to the control. The DTG thermogram exhibited the maximum thermal decomposition temperature ( $T_{max}$ ) at 207.51°C in control sample and at 206.33°C in treated sample of *p*-CBP. The result revealed about 0.57% decrease in  $T_{max}$  of treated sample with respect to the control.

The decrease in  $T_{max}$  of treated sample might be correlated with increase in vaporization or volatilization of treated *p*-CBP after biofield treatment. It might be due to alteration in internal energy through biofield energy treatment that results into earlier vaporization as compared to the control.

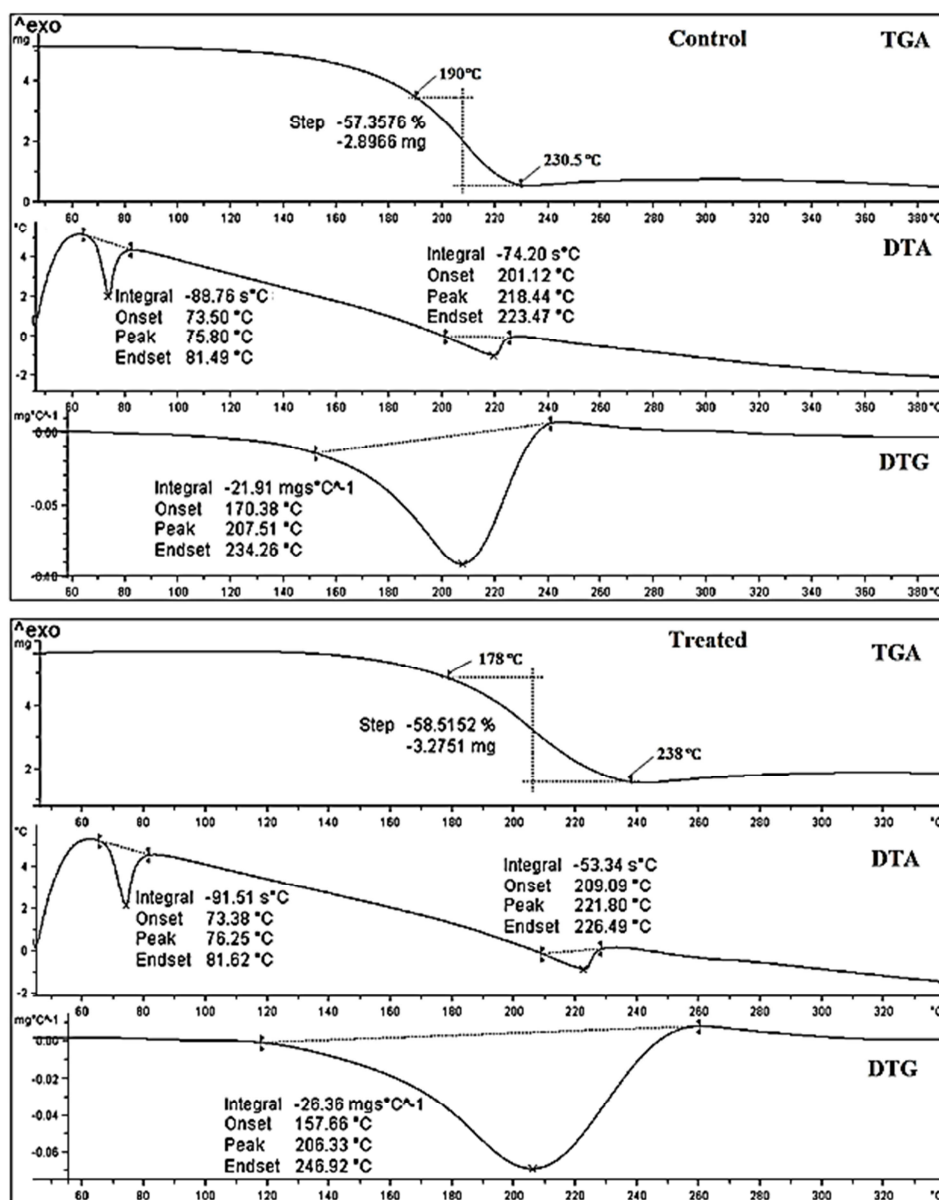


Fig. 6. TGA-DTG thermograms of control and *p*-chlorobenzophenone.

### 3.6. FT-IR Spectroscopic Analysis

FT-IR spectra of control and treated samples of *p*-CBP (Fig. 7) were interpreted based on the theoretically predicted wavenumber. The chemical structure of *p*-CBP showed mainly C=O, C=C, C-C, C-H groups vibrational peaks. The

aromatic C-H stretching peak was assigned at 3063  $\text{cm}^{-1}$  in all three samples *i.e.* control and treated (T1 and T2). Likewise, the aromatic C-H in-plane deformations were attributed to peaks 1089-1145  $\text{cm}^{-1}$  in control and 1089-1147  $\text{cm}^{-1}$  in treated (T1 and T2) samples. The C-H out of plane deformations were observed at frequency region of 729-844

$\text{cm}^{-1}$  in all three samples (control, T1 and T2). The vibrational peak of ketone (C=O) groups generally appears around  $1715 \text{ cm}^{-1}$  [32]. However, in *p*-CBP, it was appeared at  $1651 \text{ cm}^{-1}$  in control and T2 samples, whereas in T1 sample it appeared at  $1649 \text{ cm}^{-1}$ . This decreased wavenumber of C=O stretching in all three samples was observed due to extended resonance effect that lower the force constant and

thus wavenumber of C=O group stretching. The aromatic C=C stretchings were attributed to vibrational peaks observed at  $1400\text{-}1585 \text{ cm}^{-1}$  in control and  $1400\text{-}1583 \text{ cm}^{-1}$  in treated samples (T1 and T2). Similarly, the C-C stretching peak was appeared at  $1284 \text{ cm}^{-1}$  in control and T2 samples and at  $1282 \text{ cm}^{-1}$  in T1 sample of *p*-CBP.

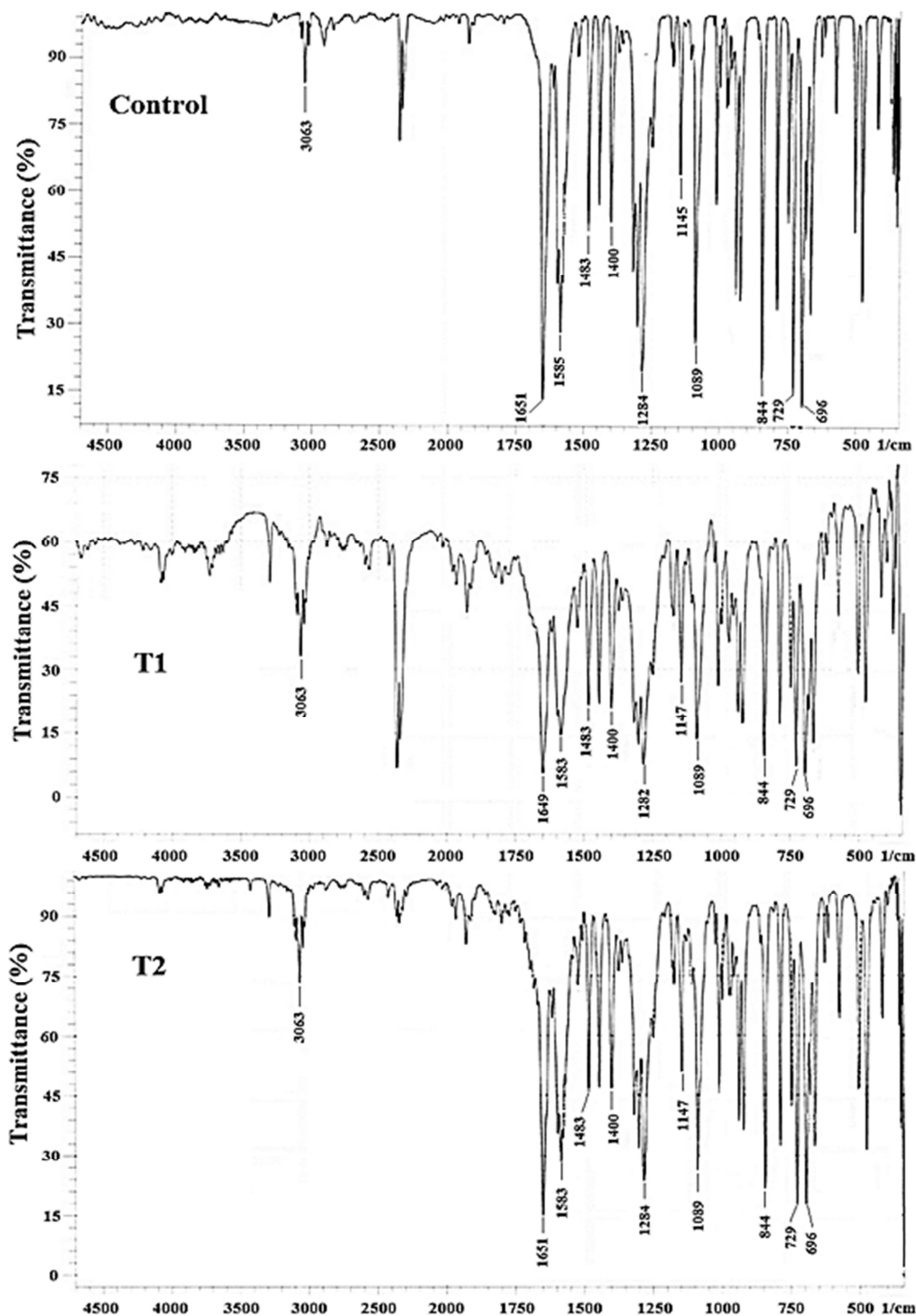


Fig. 7. FT-IR spectra of control and treated (T1 and T2) *p*-chlorobenzophenone.

Overall, the FT-IR result suggests that the biofield energy treatment did not exhibit the alteration in the wavenumber of

any bond in treated *p*-CBP as compared to the control.



### 3.7. UV-Vis Spectroscopy

The UV spectra of control and treated *p*-CBP are shown in Fig. 8. UV spectrum of control *p*-CBP exhibited the absorbance maxima ( $\lambda_{\max}$ ) at 205.0 and 257.6 nm. A similar pattern of  $\lambda_{\max}$  was observed in both the treated samples (T1 and T2) *i.e.* at 205.0 and 257.8 nm in T1 and 203.5 and 257.5 nm in T2.

Overall, the UV spectral analysis suggests that biofield energy treatment may not cause any significant alterations in the  $\lambda_{\max}$  of treated *p*-CBP samples with respect to the control. Altogether, the UV and FT-IR results, suggest that structural properties of treated *p*-CBP remained same as control.

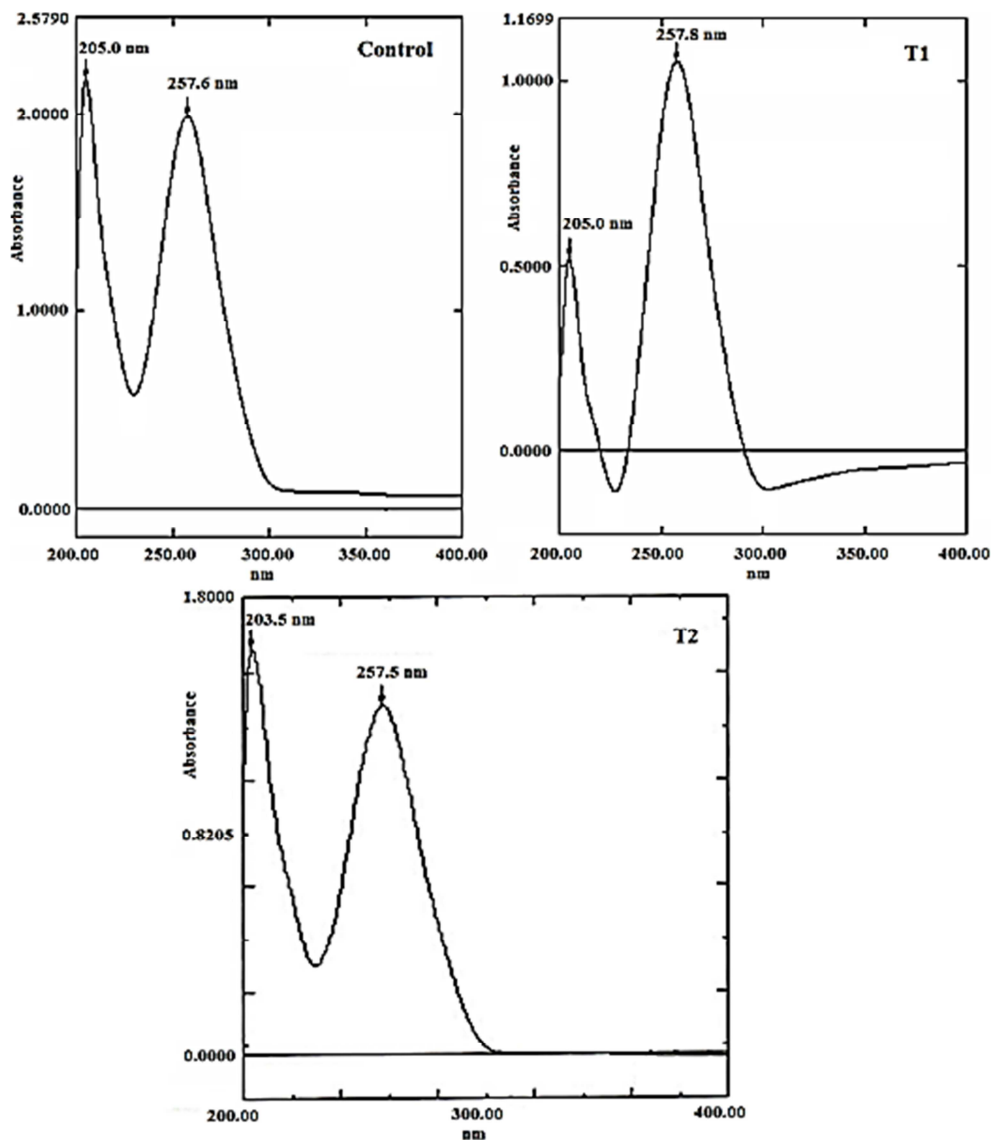


Fig. 8. UV spectra of control and treated (T1 and T2) *p*-chlorobenzophenone.

## 4. Conclusion

In summary, the XRD diffractogram of biofield treated *p*-CBP exhibited the increase in intensity of the XRD peaks as well as the average crystallite size (25.93%) as compared to the control. The particle size analysis suggests the decrease in particle size of fine particles ( $d_{10}$ ) and increase in particle size of the large particles ( $d_{90}$  and  $d_{99}$ ) with respect to the control sample. The surface area analysis showed the slight increase in the surface area of the treated *p*-CBP with respect to the control. The thermal analysis (DSC, TGA/DTG) showed a slight decrease in melting temperature and  $T_{\max}$ . However,

the  $\Delta H$  was significantly changed by 24.9% in treated sample as compared to the control. The spectroscopic analysis (FT-IR and UV-Vis) suggest that biofield energy treatment did not affect the structural properties of treated sample as compared to the control.

Altogether, it is concluded that the biofield energy treatment has the impact on physicochemical and thermal properties of treated *p*-CBP with respect to the control. Based on this, it is assumed that biofield treated *p*-CBP could be more useful as chemical intermediate for organic synthesis of various pharmaceutical drugs.

## Abbreviations

*p*-CBP: para-Chlorobenzophenone;  
 NIH: National Institute of Health;  
 NCCAM: National Center for Complementary and  
 Alternative Medicine;  
 XRD: X-ray diffraction;  
 DSC: Differential scanning calorimetry;  
 TGA: Thermogravimetric analysis;  
 DTA: Differential thermal analysis;  
 DTG: Derivative thermogravimetric analysis;  
 FT-IR: Fourier transform infrared;  
 UV-Vis: Ultraviolet-visible

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