Exceptional UV-visible light driven Photocatalytic activity over BiOI – CeO₂ Nanocomposites

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Abstract:
In this work BiOI – CeO₂ nanocomposites in three different molar ratios (1%, 3% and 5% of BiOI-CeO₂) were synthesized successfully by precipitation–deposition method and its photocatalytic activity towards Ciprofloxacin Hydrochloride (CFH) was studied. The physicochemical characteristics of the fabricated BiOI – CeO₂ composites were analyzed by UV-Vis-DRS, PL, XRD and SEM with EDAX techniques. The nanocomposite with molar ratio of 3% BiOI – CeO₂ photocatalyst possess excellent photocatalytic activity than the nanocomposite with molar ratio 1% BiOI – CeO₂, 5% BiOI – CeO₂ and the individual components BiOI, CeO₂. The band edges of materials were theoretically calculated on the basis of Mulliken electronegativity of atoms. The kinetics of the photodegradation reaction correlated with the pseudo-first-order model. The stability of nanocomposite was examined by recycling the experiments.

Key words: BiOI, CeO₂, Nanocomposites, photocatalysis.

1. Introduction:
In recent year, semiconductor –based photocatalysis has been widely used for solving the energy crisis and environmental pollution [1, 2]. However, the traditional photocatalysts have low efficiency of light absorption, slow ratio of charge transfer and the high recombination probability of the photogenerated electron - hole pairs. Thus, more and more efforts has been proposed to solve the issues [3-5], the process of coupling two kinds of photocatalysts to form composite is considered as an efficient method to resolve the above problem. Some research has been proved that construction of nanocomposites can effectively improve the separation of photogenerated electron-hole pairs and prolong the photo-absorption range, and improving semiconductors photocatalytic efficiency [6-7].
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Nowadays, rare earth oxides drawn tremendous interest in both theoretical and technological fields. Especially cerium oxide (CeO₂) has attractive and extensive application in the field of gas sensors and photocatalytic oxidation of water. On the other hand CeO₂ is one of the important semiconductors in II–IV group, which has considerable interest because of its combined properties of high surface area, high isoelectric point (IEP), mechanical strength, and excellent adsorption capability, nontoxicity, good biocompatibility, easy fabrication, plentiful oxygen vacancy, optical transparency, chemical and photochemical stability and good electro catalytic activity [8–11]. Among BiOX (X=Cl, Br, and I), BiOI is an attractive p-type semiconductor with strongest photoresponse in the visible light region due to its narrow band gap energy (1.78 eV) and is a potential sensitizer to sensitize wide band gap semiconductors [12, 13]. A number of BiOI-based heterojunctions, such as TiO₂/BiOI [14], Bi₂S₃/BiOI [15], Bi₂O₃CO₃/BiOI [16], BiOIZrO₂ [17], β-Bi₂O₃/BiOI [18], Agl/BiOI [19], ZnO/BiOI [20] and BiOI/Bi₂WO₆ [21] have been reported for photocatalytic reaction, and their results shows that BiOI–based heterojunctions exhibited enhanced photocatalytic performance under visible light irradiation. To the best of our knowledge, the coupling of BiOI with CeO₂ for photocatalytic purpose has not been reported previously.

Herein, we report the successful fabrication of crystalline BiOI-CeO₂ composites by a precipitation-deposition method and examine their photocatalytic performance towards CFH degradation under UV-visible–light irradiation. Our result indicates that the BiOI enhances the photoabsorption ability of CeO₂ in the UV-visible region. The nanocomposite of BiOI-CeO₂ improves the separation efficiency of the charge carriers which leads to the enhanced photocatalytic activity for CFH. The kinetics and the possible photocatalytic mechanism of the BiOI-CeO₂ composite are discussed in detail.

2. Experimental Section

2.1 Synthesis of CeO₂

All chemicals were of analytical grade and used as received without further purification. At First, pure CeO₂ synthesized by the homogeneous precipitation method using Cerium (III) nitrate hexahydrate (Ce(NO₃)₃.6H₂O). In a typical procedure, a measured amount of Ce(NO₃)₃.6H₂O was dissolved in 100 ml of 80% v/v ethylene glycol solution. The solution kept under constant stirring was heated at 50° C until a homogeneous solution was obtained. Then 50 mL of 5M Ammonium hydroxide (NH₄OH) was slowly added into the above solution. The transparent solution immediately changed to a yellowish suspension. The suspension was kept under stirring at 50° C for a further 24 h and the precipitate was finally collected and washed three times with deionized water and then dried at 80° C for 24 h. The obtained powder was consequently calcined at 500°C for 1 h.

2.2 Synthesis of BiOI – CeO₂ composites

The BiOI-CeO₂ composite was prepared by precipitation-deposition method. A measured amount of Bi (NO₃)₃.5H₂O was dissolved in 100 mL of distilled water containing 10 mL of glacial acetic acid and stirred for 10 min to get a clear solution. Then, the prepared CeO₂ was added into the clear solution. The combination was vigorously stirred for 30 min at room temperature. The amount of Bi(NO₃)₃.5H₂O was varied to obtain BiOI-CeO₂ composites with molar ratio 1%, 3%, and 5% respectively. The resulting mixed solution was added rapidly to 30 ml of distilled water containing stoichiometric amounts of KI. On adding, cream pink-deep red precipitate was immediately formed with the variation of Bi (NO₃)₃.5H₂O concentration from 1 to 5 mol %. The obtained precipitate was stirred for another 30 min at room temperature, and the suspension was aged for 30 h. The resulting precipitate was filtered, washed thoroughly with distilled water, and then dried at 65°C for 12 h. The neat BiOI was prepared by the same method without using CeO₂ precursor.

2.3 Characterization

The UV-Vis diffuse reflectance spectroscopy was recorded on an UV-2450 spectrophotometer (Shimadzu Corporation, Japan) using BaSO₄ as the reference. The XRD pattern obtained on an X-ray diffractmeter
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(XPERT PRO) with Cu Kα radiation at 25°C. Scanning electron microscopy observations were performed using JSM 6701F-6701 instrument in both secondary and backscattered electron modes. The elemental analysis was detected by an energy dispersive X-ray spectroscopy attached to the SEM. The BET surface area was derived from the N₂ adsorption – desorption isotherm by the Barrer-Joyn-Halenda (BJH) technique. The photoluminescence spectra of the photocatalyst were recorded using a fluorescence spectrophotometer (JASCO – FP- 6200). Photodegradation experiments were performed in a HEBER immersion type photoreactor.

2.4 Photodegradation experiment

Photodegradation experiments were conducted in a cylindrical immersion type photoreactor. Required amount of photocatalyst and CIF were added into the vessel, then pH of the solution was adjusted using 0.1 N H₂SO₄/0.1N NaOH. Before irradiation, the aqueous suspensions containing CIF and photocatalyst were continuously stirred for 30 min in dark to reach an adsorption-desorption equilibrium. After that, the mixture was subjected to UV-Vis irradiation using 150W tungsten lamp. At regular time intervals, 5 ml aliquot of the reaction mixture was collected, centrifuged and filtered through a 0.2 µm to Millipore filter to remove the photocatalyst powder. Then the filtrate was analyzed by UV-visible spectrometer at 332 nm to evaluate the residual CFH concentration. COD of CFH was estimated using the K₂Cr₂O₇ oxidation method (digesting the sample using the K₂Cr₂O₇/H₂SO₄ and subsequent titration) after the completion of photodegradation process [21]. The degradation efficiency (DE) of each catalyst was computed using the following equation.

\[ \text{DE} = \% \times \frac{(C₀ - Cₜ)}{C₀} \]  

Here Cₜ is the concentration of pollutant at irradiation time of ‘t’ min and C₀ is the concentration after the adsorption equilibrium is reached before irradiation.

![Figure 1. UV-vis diffuse reflectance spectra of BiOI, CeO₂, and BiOI-CeO₂ composites and Tuac plots of (ahv)² vs photon energy (hv) for the band gap energy of (a) BiOI (b) CeO₂ (c) 1% BiOI-CeO₂ (d) 3% BiOI-CeO₂ (e) 3% BiOI-CeO₂](image)
Figure 2. Photoluminescence emission spectra of (a) BiOI, (b) CeO2, (c) 3% BiOI-CeO2 composite.

Table 1. Estimated band gap energies (E_g) and calculated absolute electronegativity (X), E_{VB} and E_{CB} of BiOI–CeO2

<table>
<thead>
<tr>
<th>Photocatalyst</th>
<th>Absolute Electronegativity (X)</th>
<th>E_g (eV)</th>
<th>E_{VB} (eV)</th>
<th>E_{CB}(eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BiOI</td>
<td>6.20</td>
<td>1.83</td>
<td>2.61</td>
<td>0.78</td>
</tr>
<tr>
<td>CeO2</td>
<td>5.54</td>
<td>1.52</td>
<td>1.80</td>
<td>0.28</td>
</tr>
</tbody>
</table>


3.1. Optical absorption study

The light absorption properties of the BiOI, CeO2, 1% BiOI – CeO2, 3% BiOI – CeO2, and 5% BiOI – CeO2 composites are characterized by UV-vis diffuse reflectance spectroscopy. Fig.1 shows the effect of BiOI concentration on the optical properties of CeO2. The optical absorption edges of the pure BiOI and CeO2 are roughly estimated from absorption onset located at 345 nm and 468 nm, respectively. The observed result indicates that the pure CeO2 had no significant absorption in the visible region whereas BiOI has broad absorption in the visible region. When CeO2 combines with different concentrations of BiOI, the optical response of all combined samples appeared in the UV-visible region. This is due to the superposition of the absorption of the two components. Furthermore, BiOI is a potential photosensitizer which sensitizes the wide band gap CeO2 semiconductor in the visible section. The BiOI with narrow band gap (1.83 eV) could be easily activated by UV-visible light and induce photoelectrons and holes. In BiOI-CeO2 composites, the photoelectrons could easily transfer from the conduction band (CB) of BiOI to the neighboring CB of CeO2. Thus the recombination between photoelectrons and holes could be effectively inhibited, leading to the strong response in the visible region [22, 23]. The steep shape of the spectrum indicated that the visible light absorption is due to the band gap transition between BiOI and CeO2. The band gap energy of semiconductor could be calculated by using Tauc equation [24]. As shown in Fig.1 (a, b, c, d, and e) the estimated band gap
energies of the resulting samples are about 1.83 eV, 1.52 eV, 1.61 eV, 1.90 eV, and 1.78 eV for BiOI, CeO₂, 1% BiOI-CeO₂, 3% BiOI-CeO₂, and 5% BiOI-CeO₂, respectively.

The energy band gap edges [25] of BiOI and CeO₂ were theoretically predicated using the following empirical equation:

\[ E_{VB} = X - E^e + \frac{1}{2} E_g \]  \hspace{1cm} (2)

\[ E_{CB} = E_{VB} - E_g \]  \hspace{1cm} (3)

Where \( E_{VB} \) and \( E_{CB} \) is the valance band (VB) and conduction band (CB) edges potential respectively, \( X \) is the geometric mean for absolute electronegativity of the constituent atoms. The \( X \) value for BiOI and CeO₂ [26] are 6.20 and 5.54 eV, respectively. \( E^e \) is the energy of free electrons on the hydrogen scale (about 4.5 eV), and \( E_g \) is the band gap of the semiconductor. The energy band parameter of BiOI and CeO₂ were calculated, and listed in Table 1. The comparison of PL spectra of BiOI, CeO₂, and 3%BiOI-CeO₂ for excitation wavelength 350 nm is shown in Fig.2. The photoluminescence spectra of the prepared BiOI (a), prepared CeO₂ (b), and 3% BiOI – CeO₂ (c). The emission band at 413 nm corresponds to the electron–hole recombination of BiOI. The PL intensities of BiOI, CeO₂, and 3% BiOI – CeO₂ are 20, 8, and 4 au, respectively. Reduction of PL intensity at 413 nm by BiOI – CeO₂ when compared to prepared CeO₂, indicates suppression of the photogenerated electron – hole pair by loaded BiOI on CeO₂. This attributed to the fact that interfacial photogenerated electron transfer from BiOI to CeO₂ retards the charge recombination process [27].

Figure 3. XRD patterns of the as-prepared samples with different percentage of BiOI-CeO₂.

3.2. XRD analysis

The structure identity and phase composition of pure BiOI, CeO₂, and BiOI-CeO₂ composites were confirmed by powder X-ray diffraction (PXRD) pattern. Fig.3 displays the X-ray diffraction patterns of BiOI-CeO₂ composite with varying BiOI contents along with pure BiOI and CeO₂ for comparisons study. Fig. 3a can be perfectly assigned as the tetragonal phase of BiOI which coincides well with the standard data of BiOI (JCPDS card 85-0863) whereas the diffraction patterns of pure CeO₂ are consistent with the cubic
phase of CeO$_2$ (JCPDS cards 34-0394) as shown Fig. 3b. The diffraction peaks of both BiOI and CeO$_2$ became narrow and well-defined which reveals that the samples have high degree of crystallinity. The absence of any impurity related peaks in the diffraction patterns of BiOI and CeO$_2$ samples confirmed the high purity of the two products. Structurally, the BiOI-CeO$_2$ composites present a two-phase composition, i.e., tetragonal phase of BiOI and the cubic phase of CeO$_2$ with no other impurity peaks from the diffraction patterns. The intense peak of the entire BiOI-CeO$_2$ composite indicates that the samples are well crystallized. The tetragonal BiOI diffraction peaks began to appear and are gradually intensified with an increasing amount of BiOI from 1% to 5% in the BiOI-CeO$_2$ composites powder as shown in the Fig.3c-e. The characteristic peaks of BiOI (30.29°) can be found at BiOI- CeO$_2$ composites. With the increase of BiOI, the diffraction peaks intensity of CeO$_2$ become lower, while the characteristic peaks of BiOI increase in intensity. The characteristic peak of CeO$_2$ (29.91°) disappeared when the BiOI content was more than 5%. This may due to the better crystallinity of BiOI materials, and some of the characteristic peaks of BiOI coincide with that of CeO$_2$. This result suggests that BiOI and CeO$_2$ coupled together successfully. Additionally, the peaks of the BiOI-CeO$_2$ composites are broad, which seems to be that the particles of the samples are quite small. The different percentage of BiOI- CeO$_2$ was estimated using the quantitative XRD analysis based on the normalized reference intensity ratios (RIR) method, as described in our recent work [28], and was equal to Fig.3 (a, b). The average crystalline sizes of the fabricated samples were estimated by using Debye’s Scherrer equation [29]. The average crystallite size of the pure BiOI and CeO$_2$ was found to be 17.57 nm and 34.96 nm, respectively.

Figure 4
Figure 4. SEM image of a)BiOI b) CeO$_2$ c) 3% BiOI/CeO$_2$(d) EDX of 3%BiOI/CeO$_2$
Table 2. Textual Properties of BiOI, CeO₂ and BiOI-CeO₂ Nanocomposite

<table>
<thead>
<tr>
<th>Catalyst</th>
<th>Crystallite Size (nm)</th>
<th>% of degradation</th>
<th>rate constant (S⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BiOI</td>
<td>17.57</td>
<td>12</td>
<td>0.0007</td>
</tr>
<tr>
<td>CeO₂</td>
<td>38.96</td>
<td>31</td>
<td>0.0016</td>
</tr>
<tr>
<td>3% BiOI-CeO₂</td>
<td>50.34</td>
<td>74.65</td>
<td>0.0095</td>
</tr>
<tr>
<td>5% BiOI-CeO₂</td>
<td>58.54</td>
<td>61.21</td>
<td>0.0067</td>
</tr>
</tbody>
</table>

3.4. SEM and EDX analysis

The SEM image of the BiOI, CeO₂ and 3% BiOI/CeO₂ composites as displayed in Fig. 4, from which nearly closed spherical (a), cubic with leaf flak like (b) and loosely sphere like structure (c) with an average diameter of about 5Î¼m to 1Î¼m are observed. By carefully measuring the lattice parameters using a digital micrograph and comparing with the data in JCPDS, the (110) crystallographic plane of BiOI and (111) crystallographic plane of CeO₂ can be found clearly. It indicates that BiOI plane of CeO₂ have been coupled together to form the composites structure successfully. The EDX spectrum (Fig. 4d) of the 3%BiOI/CeO₂ composites contains O, I, Bi, and Ce elements and indexed in Table 2. The strong Ce peak and weak Bi, I, and O peak indicate that Ce nanoparticles were not oxidized.

Figure 5 (a) Temporal UV-Vis absorption spectral changes during the photocatalytic degradation of CFH in aqueous solution in the presence of 3% BiOI-CeO₂. (b) Effect of P25, BiOI, CeO₂ and BiOI-CeO₂ with different BiOI content on CFH photocatalytic degradation efficiency.

3.5. Photocatalytic Activity.

On the basis of the above results, we have investigated the photodegradation of CFH to evaluate the photocatalytic activity of as-synthesized BiOI-CeO₂ composites under visible light irradiation. As displayed in Fig. 5(a), the absorption of CFH in UV-visible light region significantly decrease with the increase of irradiation time and nearly disappear after 180 min. In the meantime, no additional absorption appears in the
ultraviolet region that indicates the complete destruction of aromatic structures. The characteristic absorption peak at 225 nm is employed to determine the degradation degree of CFH, and the C/C₀ vs irradiation time is plotted in Fig.5b. CFH molecules are very stable and experience almost no decomposition in the absence of catalyst, which excludes the possibility of photolysis in the present system. No obvious enhancement of degradation ratio is found when pure BiOI is used, which can be ascribed to its high recombination rate of photogenerated electron – hole pairs. As for the pure CeO₂, it also shows poor activity, on which 38.96% of CFH is decomposed after irradiation for 180 min. When CeO₂ attach with BiOI, the photocatalytic activity of nanocomposite is significantly improved for the degradation of CFH compared with pure BiOI and CeO₂. The photocatalytic activity first increase from 1% BiOI-CeO₂, and then gradually decreases with the further increase of BiOI content. This result proves that too much BiOI in the heterojunction would create an unsuitable ratio between BiOI and CeO₂ thus reducing photocatalytic activity of nanocomposites [30].

The highest activity is obtained over the 3% BiOI-CeO₂ composites, resulting in a 98.57% degradation ratio of CFH within 180 min UV-visible light irradiation. As results, 3% BiOI-CeO₂ composite is selected for the following recycling experiment.

**Fig.5b** displays the photocatalytic activities of different catalysis in the degradation of CHF under UV-visible light irradiation. Simple CFH photolysis is also performed for comparison and plank experiment in the absence of photocatalysts demonstrated that photolysis of CFH can be ignored under UV-visible light irradiation. The activity of commercial P25 is also correlated with BiOI-CeO₂ photocatalyst and the photocatalytic activity is weak, it also can be ignored under the UV-visible light irradiation. It attributed that BiOI-CeO₂ catalysts exhibit much higher photocatalytic activities than the bare BiOI, CeO₂, and the 3% at BiOI-CeO₂ shows the highest photocatalytic activity. It can be seen that the CFH degradation over bare BiOI and CeO₂ are 17.57% and 38.96% after 180 min of UV-visible light irradiation, respectively. Although the coupling of BiOI and CeO₂ is beneficial for charge separation of the BiOI-CeO₂ photocatalyst, further addition of BiOI cover on the surface of CeO₂ will hinder the UV-visible light absorption [30,31].

![Figure 6](image_url)

**Figure 6.** Cycling runs in the photocatalytic degradation of CFH in the presence of 3%BiOI- CeO₂
3.6. Stability and Reusability of 3% BiOI-CeO₂

To confirm the photocatalytic stability and reusability of the 3% BiOI-CeO₂ photocatalyst, the four circulating runs in the photocatalytic degradation of CFH under UV-vis light irradiation are checked under the same conditions. It should be mentioned that, in contrast with other catalytic processes, in a typical photocatalytic degradation of aqueous pollutants, the molar ratio between the photocatalysts and the molecule degraded is larger than 10. This fact implies that the photocatalyst should be reused several times without a significant lack of efficiency in order to be considered a catalyst rather than a regent. As shown in Fig.6, after four cycles for the photodegradation of CFH, the catalyst did not exhibit any significant loss of activity, confirming that 3% BiOI-CeO₂ is not photocorroded during the photocatalytic oxidation of the pollutant molecules, which is significant for its application. The photocatalytic mineralization of CFH by 3% BiOI-CeO₂ is analyzed to evaluate the COD removal which is determined by standard dichromate method. The analyses of COD samples are collected at every 60 min time interval during the process. The percentage of COD degradation is given in Table 3. The table explained that the COD removal from 583.86 to 194.81 mg⁻¹ decrease with increase of COD percentage (66.83%).

![Figure 7. Pseudo-first-order kinetics of (a) P25, (b) BiOI, (c) CeO₂, (d) 1%BiOI-CeO₂, (e) 3%BiOI-CeO₂, (f) 5% BiOI-CeO₂](image-url)
3.7. Possible Photocatalytic Mechanism of BiOI-CeO₂

The above results reveal that the formation of heterojunction between BiOI and CeO₂ can enhance their photocatalytic activities under UV-vis light irradiation. On the basis of experimental results, a possible UV-vis light photocatalytic mechanism of BiOI-CeO₂ composites is proposed as illustrated in Fig.8. The separated electrons and holes are then free to initiate the degradation reaction of CFH antibiotics absorbed on the photocatalyst surface. The enhanced photocatalytic process in the degradation of CFH may involve several steps: (1) The CB electron e⁻ on the surface of CeO₂ are then scavenged by oxygen on the surface of the catalyst to form super oxide radicals (O₂⁻), which again react with protons and photogenerated electrons to provide hydroxyl radicals species (OH'). (2) Holes in the BiOI may directly oxidize the organic molecules. The formations of these highly active species, i.e., super oxide radicals, hydroxyl radicals, or holes, are mostly responsible for degradation of organic pollutants [32]. The details are presented below:

\[
\begin{align*}
\text{BiOI-CeO}_2 + h\nu & \rightarrow \text{CeO}_2 (e^-) + \text{BiOI} (h^+) \quad (4) \\
\text{CeO}_2 (e^-) + \text{O}_2 & \rightarrow \text{O}_2^- \quad (5) \\
\text{O}_2^- + \text{H}^+ & \rightarrow \text{HO}_2^- \quad (6) \\
\text{HO}_2^- + \text{H}^+ + \text{CeO}_2 (e^-) & \rightarrow \text{H}_2\text{O}_2 \quad (7) \\
\text{H}_2\text{O}_2 + \text{CeO}_2 (e^-) & \rightarrow \text{OH}^- + \text{OH}^- \quad (8)
\end{align*}
\]
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\[ \text{CFH} + \text{OH}^- \rightarrow \text{degradation Products} \]  \hspace{1cm} (9)

\[ \text{CFH} + \text{BiOI} (h^+) \rightarrow \text{degradation Products} \]  \hspace{1cm} (10)

3.8 Kinetics of Photocatalytic degradation

To have a better understanding of the reaction kinetics of the CFH degradation, the experimental data are fitted by a pseudo first-order model. Figure 7 shows the first-order kinetics data for photodegradation of CFH using different catalysts. All fitting curve of the irradiation time \( t \) against \( \ln(C/C_0) \) are nearly linear. The rate constant \( k \) of 3% BiOI-CeO₂ composites are obviously larger than BiOI or CeO₂, and 1% BiOI-CeO₂, 5% BiOI-CeO₂, respectively. The enhancement implies that the coexistence of BiOI and CeO₂ gives rise to synergic effect for the 3% BiOI-CeO₂ heterojunctions, which plays an important role in the separation of photogenerated electron-hole pair [33]. To further confirm the kinetics of CFH degradation under UV-vis light over all the photocatalysts was investigated by applying the Langmuir–Hinshelwood model [34].

\[ \ln \left( \frac{C}{C_0} \right) = kt \]  \hspace{1cm} (11)

Here, \( k \) is the pseudo-first order rate constant. The plots in \( \ln \left( \frac{C}{C_0} \right) \) versus irradiation time (where \( C_0 \) is initial concentration of the antibiotics and \( C \) is the concentration of the antibiotics in the reaction time) are found to be linear regression. In all case, the \( R^2 \) (correlation coefficient) value is greater than 0.99, which confirmed the proposed rate law for CFH degradation. The apparent rate constant for BiOI, CeO₂, 1% BiOI-CeO₂, 3% BiOI-CeO₂, and 5% BiOI-CeO₂ are determined as 0.0007, 0.0016, 0.0047, 0.0095, and 0.0067 min⁻¹, respectively. The decreasing order of rate constant is summarized as follows: 3% BiOI-CeO₂ > 5% BiOI > 1% BiOI-CeO₂ > CeO₂ > BiOI, which is consistent with the photocatalytic degradation results presented in Figure 8b. The corresponding \( k \) values of BiOI-CeO₂ composites are much higher than that of BiOI and CeO₂. From the above degradation results, we conclude that all the BiOI-CeO₂ heterojunctions exhibit much higher photocatalytic activities than that of single phase BiOI and CeO₂.

4. Conclusions

In summary, the BiOI-CeO₂ composites were successfully synthesized by precipitation-deposition method and characterized by X-ray powder diffraction (XRD), scanning electron microscope (SEM), energy – dispersive spectroscopy (EDS), photoluminescence spectroscopy (PL), UV-vis diffuse reflectance spectroscopy techniques. The nanocomposites with molar ratio of 3% BiOI – CeO₂ photocatalyst possess excellent photocatalytic degradation of CFH when compared to 1% BiOI – CeO₂, 5% BiOI – CeO₂, and BiOI and CeO₂, respectively.

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References:


