# Enhancing photocatalytic performance of BiOX for Bisphenol – A degradation

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## Abstract

A heterojunctionBiOI<sub>0.5</sub>Br<sub>0.5</sub> was prepared for enhancing the photocatalytic performance of BiOX (X= Br or I) by facile method at room temperature using Bismuth Nitrate Bi(NO<sub>3</sub>)<sub>3</sub>.5H<sub>2</sub>O as Bismuth source. All prepared materials were fully identified by the required characteristics. The effect of heterojunction as well as BiOBr and BiOI on the photocatalytic activities were studied through degradation of widely used endocrine disturbing compound, Bisphenol - A, in aqueous solution under commercial visible lamp. The percent removal of Bisphenol- A was 55%, 79% and 93% with BiOBr, BiOI and BiOI<sub>0.5</sub>Br<sub>0.5</sub> respectively after 120 min irradiation time using 1.0 g/L dose of photocatalysts and pH10. Accordingly, heterostructure considered a promising method that can be used to enhance pure photocatalyst for degradation of organic pollutants in water. Copyright © 2018 VBRI Press.

Keywords: Heterostructure, BiOX, photocatalysis, bis-phenol – A degradation.

## Introduction

For the time being water pollution is one of the serious problems and challenges that humanity faces where Human activities introduce contaminant materials and wastes into rivers, lakes and groundwater aquifers. Among these contaminant, Endocrine Disturbing Compounds (EDCs) group is one of the largest groups of pollutants found that can affect the hormonal system,<sup>[1]</sup>most EDCs that have recently received scientific and public attention are phthalates, Bisphenol-A and Chlorophenols.<sup>[2]</sup> Bisphenol-A (BPA) used in the production of polycarbonate polymer since; it is used as a resin in different industries. EDCs have been listed as hazardous pollutants by Environmental Protection Agency and the European Union because of its tendency to start estrogenic activity even in low concentrations.<sup>[3]</sup>

TiO<sub>2</sub>basedPhotocatalysis has been used for a long time but the problem is derived from the mismatch between the TiO<sub>2</sub> band gap energy and sunlight spectra, which can only take advantage of UV light, Therefore, it favorable to prepare visible-light responsive is photocatalyst and to follow the photocatalytic power of the prepared materials indevolution of different pollutants that can be detected in water.<sup>[4]</sup>

The progress of photocatalysts that absorb light over broad extent of wavelengths and enhancing а chargecarriers dismiss continue an interest point for Bismuth-based advancements. photocatalysts are important topic in the future prospective as strong visiblelight-absorption photocatalyst.<sup>[5]</sup>

Currently, bismuthoxyhalides (BiOX, X= Cl, Br, I) and heterojunction, performed photocatlysts, which have

special properties and different applications have been established for photocatalysis process under visible light.In the case of heterojunction ,BiOX, (X= Cl, Br, I) have favorable band edge for desired construction, which exhibit high separationefficiency of electron-hole pairs and thus enhance the photocatalytic activities of BiOX.<sup>[5-</sup> <sup>6</sup>So, the heterostructures can achieve advantage for the photocatalyst to get rid of its photoreduction and have high photocatalytic oxidation for different pollutants.<sup>[7]</sup>

The formation of heterojunctionsis the future potential occurred by loading of a noble metal, semiconductor combination, metal and nonmetal doping, carbon-based material modification, and Bi metal loading.<sup>[5]</sup>

Li and co-workers reported that the formation of junctions between anatase- and rutile-phase TiO<sub>2</sub> as well as the formation of junctions between  $MoS_2$  and CdScan enhance the photocatalytic activity.<sup>[8,9]</sup> Also  $Ag_2O/Ag_2CO_3$ ,<sup>[7]</sup>  $Ag_2O/TiO_2$  nanotube can be considered as a conventional heterojunctions.[10]

Recently, many novel heterostructures bismuthcontaining photocatalysts have been widely combined with other semiconductorshas been used such as CdS/BiPO<sub>4</sub>,<sup>[11]</sup> and BiOBr/C<sub>3</sub>N<sub>4</sub> to construct heterojunctions with enhanced photo activity. <sup>[12]</sup>Meanwhile, various heterojunction derived from BiOI are exceedingly applied as photocatalysts in several environmental enforcement as example BiOI/B2WO6,[13] BiOI/Bi<sub>2</sub>MoO<sub>6</sub>,<sup>[14]</sup> BiOI/Ag<sub>3</sub>VO<sub>4</sub>,<sup>[15]</sup> BiOI/Bi<sub>2</sub>O<sub>2</sub>CO<sub>3</sub> and BiOI/BiOBr.<sup>[16,17]</sup> In the same time, bismuth- containing semiconductors photocatalysts with other were investigated in water treatment such as Bi2O3/CeO2and Bi2SiO5/AgI.[18-19]

Bismuth oxyhalides were implemented in dyes photodegradation like Rhodamine B,<sup>[16]</sup> methyl orange,<sup>[17]</sup> BF dye,<sup>[15]</sup>orangeII, ARG, and Azure B.<sup>[18-20]</sup> BiOXs have also been applied in organic removal, disinfection and heavy metal reduction from water such as Chromium (VI).[13-14,21-23] The studies have demonstrated that they have high performance under visible light. Accordingly, BiOX and bismuth-containing photocatalysts have high interest and are widely used under visible light irradiation due to their important effect in preventing the recombination of charge carriers as well as acting as visible-light sensitizers. It is obvious in the tabulated comparison of the reported work with previously reported literature that bismuth-containing photocataysts or heterojunction derived from BiOI have an important effect in the performance of photocataysis.

 Table 1. Previously reported literature for bismuth-containing photocataysts.

Catalyst	Eg (eV)	Pollutant	Kapp (miā <sup>l</sup> ) &% removal	The cited work
$\mathrm{Bi}_{2}\mathrm{WO}_{6}$	2.88	Toluene	0.0021	Lin et al.,2013 <sup>[13]</sup>
BiOI	1.76	Toluene	0.0014	Lin et al.,2013 <sup>[13]</sup>
18.5%BiOI /Bi <sub>2</sub> WO <sub>6</sub>	2.07	Toluene	0.0092	Lin <i>et a</i> 1.,2013 <sup>[13]</sup>
CeO <sub>2</sub>	3.1	Orange II	0.0015	Hsieh <i>etal.</i> ,2013 <sup>[18]</sup>
Bi <sub>2</sub> O <sub>3</sub>	2.84	Orange II	0.0004	Hsieh et al.,2013 <sup>[18]</sup>
Bi <sub>2</sub> O <sub>3</sub> /CeO <sub>2</sub>	2.39	Orange II	0.00119	Hsieh <i>et al.</i> ,2013 <sup>[18]</sup>
$Bi_2MoO_6$	2.59	BPA	0.0087	Yan <i>et al.</i> ,2015 <sup>[14]</sup>
BiOI	1.85	BPA	0.0028	Yan et al., 2015 <sup>[14]</sup>
25%BiOI/ Bi <sub>2</sub> MoO <sub>6</sub>		BPA	0.0781	Yan <i>et al.</i> ,2015 <sup>[14]</sup>
Ag <sub>3</sub> VO <sub>4</sub>	2.2	BF dye	25%	Wang et al.,2015 <sup>[15]</sup>
BiOI	1.86	BF dye	65%	Wang et al.,2015 <sup>[15]</sup>
$\begin{array}{c} 30wt\%BiOI\\/Ag_3VO_4 \end{array}$		BF dye	97%	Wang <i>et al.</i> ,2015 <sup>[15]</sup>
BiOBr	2.81	МО	0.085	Liu et al.,2014 <sup>[17]</sup>
40%BiOI/ BiOBr	1.98	МО	0.180	Liu <i>et al.</i> ,2014 <sup>[17]</sup>
Bi <sub>2</sub> O <sub>2</sub> CO <sub>3</sub>	3.26	RhB	0.00078, 6.6%	Liu <i>et al.</i> ,2015 <sup>[16]</sup>
BiOI/	1.8	RhB	0.04495,9	Liu et al.,2015 <sup>[16]</sup>
Bi <sub>2</sub> O <sub>2</sub> CO <sub>3</sub>			7.8%	
Bi <sub>2</sub> SiO <sub>5</sub>	3.54	ARG		Wan et al.,2015 <sup>[19]</sup>
AgI	2.76	ARG	0.043	Wan et al.,2015 <sup>[19]</sup>
Bi <sub>2</sub> SiO <sub>5</sub> / AgI		ARG	0.138	Wan <i>et al.</i> ,2015 <sup>[19]</sup>
BiOBr,	2.9	BPA	55%	The reported work
BiOI and	1.9	BPA	79%	The reported work
BiOI <sub>0.5</sub> Br <sub>0.5</sub>	2.1	BPA	93%	The reported work

In the present study, the photocatalytic degradation of successfully prepared  $BiOI_{0.5}Br_{0.5}$  heterojunction will be investigated compared with BiOBr and BiOI using bisphenol - A. Accordingly, the principle of the current work is preparation of the heterojunction (BiOI/BiOBr) in order to overcome the drawbacks of synthetizing the single-component photocatalysts (BiOI and BiOBr) and to combine the advantages of the individual components.

## Experimental

## Material

BPA of purity 99% were purchased from Sigma Aldrich Company and were used without further purification. All the reagents used for preparation of photocatalysts Bismuth nitrate pentahydrate (Bi  $(NO_3)_3 \cdot 5H_2O)$ , sodium bromide (NaBr), and potassium iodide (KI) were supplied from Merck company. Orthophosphoric acid 98%, sodium hydroxide 98% and glacial acetic acid used for pH adjustment and absolute ethanol used for washing of the prepared photocatalyst were submitted by Merck Company submitted by Merck Company.

## Material synthesis

BiOBr was synthesized by dissolving bismuth nitrate penta hydrate 0.05mole (Bi(NO<sub>3</sub>)<sub>3</sub>.5H<sub>2</sub>O) in aqueous 0.5M 100 mL sodium bromide solution with magnetic stirring for 24h at room temperature. The precipitate was collected and rinsed with de-ionized water and absolute ethanol several times, then dried for 6h at 60°C. Meanwhile, BiOI was prepared by magnetic stirring for 30 min of 0.05mole Bi(NO<sub>3</sub>)<sub>3</sub>.5H<sub>2</sub>O in 450 mL di-ionized water. Then, 0.5 M 100 mL potassium iodide was added drop wisely into the above solution and the mixture was heated for 5h at 80 °C in water bath. The resulting collected precipitates were washed and dried for 4h at  $60^{\circ}$ C in air. Finally, BiOI<sub>0.5</sub> Br<sub>0.5</sub> heterojunction was prepared by dispersing 2.00g of BiOBr as previously mentioned into 400 mL deionized water adjusted to pH 2.65 by glacial acetic acid with constant stirring. Then, a stoiciometric amount of KI was added drop wisely into the suspension solution of BiOBr. The mixture was stirred for 30 min at room temperature. Finally, the vellowish orange BiOI<sub>0.5</sub>Br<sub>0.5</sub> precipitates with molar weight % in [I/(I+Br)] ratio 50% were collected, washed and dried at 80°C for 3 hrs. [24-26] Absolute ethanol and deionized water were used for rinsing the collected precipitates several times.

## **Characterizations**

Philips powder diffractomete, JEOL JEM-2100 High Resolution Transmission Electron Microscopy (HRTEM), NOVA Surface Area Analyzer, UV-Vis spectrophotometer (JASCO V-570), were used for characterization of the prepared photocatalyst powders for X-ray diffraction (XRD) the XRD patterns measurements of all the samples were collected at room temperature and performed by Philips powder diffractometer in the reflection mode (Cu KR radiation, $\lambda$ =1.5418 Å) and scan rate of 2°C/min.DTA [STERAM Labsys<sup>™</sup> TG-DSC1600°C] apparatus with heating rate 5°C., morphology by dispersing the final powders in ethanol and the dispersion was dropped on carbon-copper grids. Then, the obtained powders deposited on a copper grid with operating at an accelerating voltage of 200 kV., the Brunauer–Emmett–Teller (BET) surface area The specific surface area of the marigold-like BiOX powders were measured from the nitrogen adsorption analysis. Nitrogen adsorption-desorption isotherms were collected on a Quantachrome Nova Automated Gas sorption analyzer at 77 K after the sample had been degassed in the flow of N<sub>2</sub> at 180°C for 5 h. The BET surfacearea was calculated from the linear part of the BET plot ((P/P0) = 0.1-0.25)., UV-Vis diffuse reflectance spectra with wavelength 190-2500 *nm*by measuring the reflectance of the powders at room temperature then converted from reflection to absorbance by the Kubelka Munk method.respectively.

#### Device fabrications

Photocatalytic reactor equipped with visible light source of commercial visible metal halide lamp (HQI-T 250/Daylight, OSRAM GmbH, Germany), cooling jacket and Magnetic stirrer were used for photocatalytic degradation of BPA. 3-5 ml samples were taken from the reaction suspension at given time intervals.

#### **Response measurements**

UV–Vis spectrophotometer (JASCO V-630) was used to determine the concentration of BPA with simple spectrophotometric method during the photocatalysis process, in terms of the characteristic absorption bands for BPA at  $\lambda$  max 275 *nm*.

#### **Results and discussion**

#### Characterization

The XRD charts elucidated in (Fig. 1) showed a pure tetragonal single phase of the prepared materials (BiOBr, BiOI and BiOI $_{0.5}Br_{0.5}$ ). Since, the presented peaks only belong to BiOBr, BiOI and BiOI $_{0.5}Br_{0.5}$  in correspondence to JCPDS file Card No.09-0393 and No.10-0445 for BiOBr and BiOI respectively. Narrow and intense peaks reveal good crystallinity of all prepared photocatalysts.



Fig. 1. XRD patterns of prepared materials. (a) BiOBr, (b) BiOI and (c) BiOI/BiOBrheterojunction.



(**Fig. 2.** TEM images of the prepared photocatalysts.) (a) BiOBr,(b) BiOI and (c) BiOI/BiOBrheterojunction.

**Fig. 2** shows the microstructure and morphology of the prepared photocatalysts investigated by TEM. The TEM images showed smooth surface for all prepared materials with irrigular microsphere form for BiOBr, irregular nanoplates form for BiOI (**Fig. 2a and Fig. 2b**). Hence the irrigular nanoplates-microsphere style was observed for BiOI<sub>0.5</sub>Br<sub>0.5</sub> heterojunction (**Fig. 2c**).

UV–Vis diffuse reflectance spectra analysis in (**Fig. 3**) showed red shift with increasing X atomic numbers which is in accordance with Jia et al., 2011. <sup>[27]</sup> An intense absorption edges in the visible light region were observed for all the prepared catalysts at 440 nm, 645 nm and 700 nm with BiOBr, BiOI and BiOI<sub>0.5</sub>Br<sub>0.5</sub> respectively.

The absorption coefficient ( $\alpha$ ) in Kubelka – Munk (KM) equation can be calculated through the information obtained by the diffuse reflectance to correlate the value of the band gap to UV-Vis absorption limit: <sup>[28]</sup>

$$F(\mathbf{R}_{\infty}) = \alpha / S_{=} (1 - \mathbf{R}_{\infty})^{2} / \mathbf{R}_{\infty}$$
<sup>(1)</sup>

where  $F(R_{\infty})$  and S are KM function and scattering coefficient respectively. It is recognized that for semi conductors the optical absorption close the band gap obeys equation (2):

$$\alpha E = C(E - E_g)^n \tag{2}$$

where C,  $E_g$ , and E are a constant, the band gap energy and incident photon energy, respectively. The value of exponent (n) is assigned to (1/2) which is the case for the studied photocatalysts. The KM function can be utilized instead of  $\alpha$  for estimation in the diffused reflectance spectra.

Diffuse reflectance spectroscopy transformed to absorbance and drawn against wavelength as presented in (**Fig. 3**). Meanwhile, inset of (**Fig. 3**) explains that band gap energies were 2.9, 1.9 and 2.1 eV for BiOBr, BiOI and BiOI<sub>0.5</sub>Br<sub>0.5</sub> respectively which resulting from the correlation between  $(F(R_{\infty})E)^{1/2}$  and photo energy. <sup>[29]</sup>



Fig. 3. UV–Vis DRS of the prepared photocatalysts, Inset: Plots of  $F(R_{\rm x})E)^{1/2}$  versus photo energy.

Nitrogen adsorption analysis was used to measure the specific surface area and porosity of the prepared photocatalysts. A type-IV isotherm, typical to mesopores solids, was exhibited for all the prepared photocatalysts as shown in (**Fig. 4**).

The BJH method was utilized for the determination of characteristic surface area (A<sub>BET</sub>) for the prepared materials which were in the order BiOI (296.6 m<sup>2</sup>/g) > BiOI\_{0.5}Br\_{0.5} (186.6 m<sup>2</sup>/g) >BiOBr (6.19 m<sup>2</sup>/g). Unexpected variation in the calculated surface area presupposed that surface area may influence their photocatalytic execution.



Fig. 4.  $N_2$  adsorption and desorption isotherms for the Prepared photocatalysts. (a) BiOBr microspheres (b)BiOI/BiOBr heterojunction (c) BiOInanoplates.

### Photocatalytic degradation

During the photocatalysis process the irradiation time must be optimized. (**Fig. 5a**) presents the degradation time experiment (180 min) of 40 mg/L BPA by 0.75 g/L of the synthesized photocatalysts at pH 6.5. The degradation rate was increased with time till 120 min then there was no significant increase in degradation observed. The maximum removal obtained was 39% (BiOBr), 46% (BiOI) and 55% (BiOI<sub>0.5</sub> Br<sub>0.5</sub>). Accordingly, 120 min can be taken as the optimum irradiation time for BPA degradation.



**Fig. 5.a.** % removal as a function of irradiation time on the photocatalytic degradation of BPA [pH 6.5, dose of catalyst 0.75 g/L, BPA concentration 40 ppm].



Fig. 5.b. Degradation rate constant of BPA under visible light irradiation using various doses BiOBr, BiOIandBiOI/BiOBrheterojunction.

The amount of catalyst expended per cycle is an important factor in photocatalytic degradation accordingly, the optimum dose must be determined. (Fig. 5b) shows the degradation rate constant against catalyst dose at 120 min, 40 ppm of BPA at room temperature.

Increment of catalyst loadings from 0.25g/L to 1 g/L was accompanied with increment in the degradation rate constants this can be caused by increasing the amount of hydroxyl radical obtained by increasing catalyst dose due to growth in the number of e/h pairs resulted from the more available active sites. <sup>[30-31]</sup> Increasing catalyst loading to 1.25 g/L leads to adverse effect on the catalytic activity because of the turbidity increment leading to lower breakthrough and high light scattering effect.<sup>[32-33]</sup>Accordingly, a dosage of 1.0g/L should be selected as the optimum dosage.

Effect of solution's pH value on the degradation of BPA is an interesting parameter to study where it is a critically operational variable. <sup>[34 - 35]</sup>Since variation in the pH values of the solution give rise to fluctuation of the stationary electric charges through the BPA and the superficial of the prepared photocatalysts. <sup>[36]</sup>

Degradation of BPA affected by pH of the solution with the prepared photocatalysts is showed in (**Fig. 5c**).



Fig. 5.c. Degradation rate of BPAat different pH values under visible light irradiation usingBiOBr,BiOIandBiOI/BiOBrheterojunction.

The effect of pH on degradation of BPA by the prepared photocatalysts is presented in (**Fig. 5c**) that shows degradation rate constant against different pH values (3 - 11) at 120 min, 40 ppm of BPA at room temperature, the normal pH of the solution was detected to be 6.4. Increasing pH value from 3 to11 showed increase in the degradation rate constant till pH10 then decrease in degradation rate constant takes place.

This can be resulted from the impact of pH on superficial charge on the photoctalyst and BPA also the presence of the active hydroxyl species that have a great effect on the degradation efficiency. Change in H<sup>+</sup> and OH<sup>-</sup> concentrations For BiOX, as an amphoteric material, can affect its net surface charges which play the main rule in degradation.<sup>[37]</sup>

In acidic solution (pH <7.0) lower degradation rate is observed due to positive charge of catalysts and BPA. In alkaline media, in photo oxidation At photo oxidation reaction can occur in basic media since the e/h pairs formed on the surface of the prepared photocatalysts can react with the hydroxide ions (OH<sup>-</sup>) forming large number of active speciesas shown in equations (3-9).<sup>[38,26]</sup> Accordingly, as the pH of the solution increased the photocatalytic oxidation rate increase. Contrary, increasing pH value than 10 decreases the degradation rate because BiOX and BPA molecules may repel at higher pH leading to lower absorption of BPA on the surface of the prepared photocatalysts.<sup>[21]</sup>

$$BiOX+hv (\lambda < 400nm) \rightarrow BiOX (e_{cb-}+h_{vb})$$
(3)

$$BiOX (e_{cb-}) + O_2 \rightarrow BiOX + O_2^{-}$$
(4)

 $h^+ + H_2 O \to O H^{-} \tag{5}$ 

 $e^{-}+O_{2}\rightarrow O_{2}^{-}\rightarrow H_{2}O_{2}\rightarrow 2OH^{-}$  (6)

 $h^+ + OH^- \to OH^- \tag{7}$ 

 $h_{vb+} + BPA \rightarrow biproducts$  (8) OH:+ BPA > biproducts (9)

$$OH + BrA \rightarrow opproducts$$
 (9)

Different concentrations of BPA were degraded using the prepared photocatalysts at optimum conditions (1.0 g/L photocatalyst dose, pH10, 120 min contact time at room temperature using 10-40 ppm BPA initial concentration). The relationship between BPA concentration and degradation activity represented by degradation rate constant is associated with the BPA surface of photocatalyst.<sup>[39]</sup> the absorption on Therefore, increasing BPA concentration decreases activity as shown in (Fig. 5d) because of the low available number of active species on the photocatalyst surface in BPA solution.<sup>[40]</sup> Also, more organic intermediates can be formed by increasing BPA concentration. These intermediate compounds may compete with OH<sup>-</sup> for absorption at the active sites of photocatalysts, leading to lower hydroxyl radicals that may be formed.<sup>[32,41]</sup>

The photo oxidation reaction rate decreases in the order  $BiOI_{0.5}Br_{0.5}>BiOI>BiOBr$  under visible light irradiation as presented in (**Fig. 5d**). The photocatalytic degradation of BPA followed the pseudo-order kinetics according to equation (10).



**Fig. 5.d.** pseudo first order kinetic of BPA degradation using the prepared photocatalysts with BPA different concentration.

$$LN(C/C_o) = K_{app}t \tag{10}$$

the optimum conditions, heterojunction At BiOI<sub>0.5</sub>Br<sub>0.5</sub> showed the highest removal although itdoes not have the lowest band gap energy. This may be attributed to the effect of band structure on controlling the properties of photocatalysts. Where in pure BiOBr and BiOIthe band edges cannot enhanced the separation of electron, hole pairs. Meanwhile in the heterojunction the valence band edge of BiOI get a higher potential edge. So, the modified band edges for the heterojunction is an interactive structure where the electrons and the photogenerated holes are in continuous movement trough the transfer of electron in CB of BiOI into the more positive CB of BiOBr and holes in the VB of species  $O_2^-$  and  $H_2O_2$  that react directly organic pollutants [11,12,15, 25,26] BiOBr to the VB of BiOI .resulting of active

Accordingly, the enhanced photocatalytic activity of pure BiOI and BiOBr are achieved through the heterojunction structure which leads to the improvement of photocatalyst absorption capacity and high photo oxidation activity.<sup>[42]</sup>

It is important to report that, phenolic degradation under visible light has not been extensively reported while degradation under UV irradiation has been relatively more widely reported.<sup>[43-44]</sup>

(Fig. 6) shows the UV–visible spectrum changes of BPA in the photocatalytic process at optimum condition and efficiency of prepared photocatalyst where at the peak around 275nm as the photocatalytic reaction proceeded, the absorbance in the UV region decreased which suggested the cleavage of the aromatic rings also a sharp decrease after 15 min of reaction was observed which reflecting the formation of intermediates. But, a relatively strong absorbance in the UV - Vis region was observed even after 60 min in BiOBr, indicating that some aromatic intermediates still remained in the solution even though most of BPA was degraded with BiOI and BiOI<sub>0.5</sub>Br<sub>0.5</sub>. So, the photo oxidation reaction activity of BiOI<sub>0.5</sub> Br<sub>0.5</sub> heterojunction is morelarge than that of BiOI and BiOBr in single form.



Fig. 6. UV–Vis spectroscopy for Photocatalytic oxidation of Bisphenol-Aat  $\lambda$  max275 nm.

### Conclusion

In this paper, BiOI<sub>0.5</sub>Br<sub>0.5</sub> heterojunction and its parents were prepared, fully characterized and their photocatalytic degradation under visible light was compared by photodegradation of bisphenol - A. Although, BiOI<sub>0.5</sub>Br<sub>0.5</sub> heterojunction has intermediate surface area and band gap energy between BiOBr and BiOI but it was shown to have higher photocatalytic activity due to its band structure. 1 g/L BiOI<sub>0.5</sub>Br<sub>0.5</sub>heterojunction removed 93 % of 40 ppm bisphenol - A after 120 min at pH10 while, the same dose of BiOI and BiOBr removed 55% and 79% of 40 ppm bisphenol - A respectively under the same conditions. UV-visible spectrum changes of BPA showed peak around 275nm. Following bisphenol - A degradation confirms that the aromatic ring is cleaved after 15 min in case of BiOI and BiOI<sub>0.5</sub>Br<sub>0.5</sub>heterojunction but it is still present in case of BiOBr even after 60 min.

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