# Ultrasonic synthesis and characterization of CuO/Cu<sub>2</sub>O composites as visible-light-driven photocatalyst

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The heterojunction CuO/Cu<sub>2</sub>O sample was prepared successfully via ultrasonic method with varying amounts of NaBH<sub>4</sub> for photodegradation of rhodamine B (RhB) and photoreduction of hexavalent chromium ions (Cr(VI)) under visible light irradiation. XRD patterns of asprepared heterojunction CuO/Cu<sub>2</sub>O samples confirmed the coexistence of binary phase of monoclinic CuO structure (JCPDS no. 45-0937) as minor phase and cubic Cu<sub>2</sub>O (JCPDS no. 05-0667) as major phase. SEM and TEM images of heterojunction CuO/Cu<sub>2</sub>O sample demonstrated the agglomerated assembly nanoparticles and microparticles in shape. The UV–vis DRS spectra of heterojunction CuO/Cu<sub>2</sub>O samples of 2.41-2.25 eV. The photocatalytic efficiencies over the as-synthesized CuO/Cu<sub>2</sub>O samples with 0.20 g of NaBH<sub>4</sub> showed the 89.23% of RhB degeadation and 72.81% of Cr(VI) reduction under visible light illumination. Moreover, the photocatalytic mechanism and photocatalytic stability of CuO/Cu<sub>2</sub>O composite were studied and proposed based on the experimental result in this research.

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### 1. Introduction

In decade years, the increasing levels of persistent organic pollutants, including pesticides, synthetic organic dyes, herbicides, and pharmaceuticals, in various water sources have raised significant concerns about their potential environmental and human and organism health impacts [1, 2]. Traditional wastewater treatment methods including coagulation, filtration, precipitation, flotation and adsorption are largely ineffective in removing these pollutants due to their low biodegradability and create the secondary solid waste [3-5]. Semiconductor-based photocatalysts are an effective and cost-efficient approach for addressing large-scale environmental pollution due to the cost-effective, high stable, strongly oxidizing, environmentally friendly, and non-toxic for photocatalytic reactions [6, 7]. Among these, TiO<sub>2</sub> and ZnO are particularly suitable for photocatalytic application because of their non-toxicity, wide bandgap, and high photosensitivity [8-10]

Semiconductor copper oxide-based photocatalysts, p-type semiconductor cuprous oxide (Cu<sub>2</sub>O) (band gap energy ( $E_g$ ) = 2.20 eV) has been used in visible-light-driven photocatalyst due to its strong visible light response, non-toxicity, high stability and good chemical and physical

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properties [11-13]. In theory, the single semiconductor copper oxide-based photocatalyst was limited in practical photocatalytic application due to fast photo-generated electron-hole pairs [14, 15]. To solve this problem, the constructive p-n heterojunction copper oxide-based photocatalyst is an effective increase the photocatalytic performance due to create the internal electric filed at p-n heterojunction and accelerate the photogenerated carrier pairs migration at p-n heterojunction copper oxide-based photocatalyst [15-17]. The n-type semiconductor copper oxide (CuO) ( $E_g = 1.50 \text{ eV}$ ) has garnered considerable attention in photocatalysis due to its good electron mobility, narrow band gap, and more efficient in absorption in solar light spectrum, making its highly effective for photocatalytic application [13, 17-19]. Therefore, the formation of CuO/Cu<sub>2</sub>O heterojunction was improved the photocatalytic performance due to the effectively facilitated the separate rate of photogenerated charge pairs in photocatalytic reaction [16, 20].

In this work, the p-n heterojunction CuO/Cu<sub>2</sub>O sample was prepared with varying amounts of NaBH<sub>4</sub> by ultrasonic method. The structure, phase composition, oxidation number of element, morphologies, photoluminescence and optical properties of as-synthesized CuO/Cu<sub>2</sub>O composite were analyzed and discussed in this study. The photodegradation and photoreduction performances of CuO/Cu<sub>2</sub>O composites under visible light irradiation were investigated by degradation of rhodamine B (RhB) as cationic azo dye model and reduction of hexavalent chromium (Cr(VI)) as heavy metal model.

#### 2. Experimental method

To synthesize heterostructure CuO/Cu<sub>2</sub>O photocatalyst by ultrasonic method, 0.01 mole of CuSO<sub>4</sub>·5H<sub>2</sub>O was dissolved in 50 mL of reverse osmosis (R.O.) water. Next, 50 mL of 0.01 mole of NaOH solution was slowly added into the Cu<sup>2+</sup> solution under magnetic stirring. Then, the different weights of 0.05, 0.10, 0.15, 0.20, and 0.25 g of NaBH<sub>4</sub> solution with noted as C1, C2, C3, C4, and C5, respectively, were added into the copper solution. The mixture was transferred to an ultrasonic bath (480 W) with an ultrasonic frequency of 35 kHz and sonicated for 2 h. Finally, the heterostructure CuO/Cu<sub>2</sub>O photocatalyst was filtered, washed, and dried for further characterization.

The photodegradation of rhodamine B (RhB) and the photoreduction of hexavalent chromium (Cr(VI)) from K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution by the as-synthesized photocatalyst were studied in this research. The as-synthesized photocatalyst (1.0 g/L) was added into the 30.0 mL of 1.0 x  $10^{-5}$  M RhB solution or 30.0 mL of 1.0 x  $10^{-3}$  M K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution under stirring in the dark for 30 min. Subsequently, the mixture was irradiated under a 50 W visible light LED lamp and 2.0 mL of the solution were collected at different time intervals. The absorptions of toxic pollutants were measured at  $\lambda_{max}$  of 554 nm for RhB and 350 nm for Cr(VI) using UV-visible spectroscopy.

#### 3. Results and discussion

The X-ray diffraction (XRD) patterns of as-synthesized CuO/Cu<sub>2</sub>O samples with the difference weight of NaBH<sub>4</sub> (from 0.05 g to 0.25 g) are shown in Fig. 1. The patterns can be indexed to the mixed phases of monoclinic CuO (JCPDS no. 45-0937) and cubic Cu<sub>2</sub>O (JCPDS no. 05-0667) crystal structures. The diffraction peaks at  $2\theta = 29.59^{\circ}$ ,  $36.48^{\circ}$ ,  $42.35^{\circ}$ ,  $52.61^{\circ}$ , and  $61.39^{\circ}$  are corresponding to the (110), (111), (200), (211), and (220) planes of the cubic Cu<sub>2</sub>O phase, respectively. Meanwhile, the diffraction peaks at  $2\theta = 35.72^{\circ}$ ,  $38.62^{\circ}$ ,  $38.92^{\circ}$ ,  $46.17^{\circ}$ , and  $53.46^{\circ}$  are corresponding to the (002), (111), (200), (-112), and (020) planes of the monoclinic CuO phase [21, 22]. The results confirm that the Cu<sup>2+</sup> ions were reduced to Cu<sup>+</sup> ions by NaBH<sub>4</sub> as a reducing agent to synthesize the cubic Cu<sub>2</sub>O phase. The presence of intense and sharp diffraction peaks were observed in all CuO/Cu<sub>2</sub>O samples, suggesting that products were well crystallized in nature. The impurities phases were not detected in XRD pattern of CuO/Cu<sub>2</sub>O samples, indicating that the samples were composed of only the monoclinic CuO and cubic Cu<sub>2</sub>O phase. When increasing the amout of NaBH<sub>4</sub>, the diffraction intensity peaks of monoclinic CuO phase were decreased whereas the diffraction intensity peaks of cubic Cu<sub>2</sub>O phase were increased, implying that the formation of cubic Cu<sub>2</sub>O phase was influenced by concentration of NaBH<sub>4</sub> solution. The phase percentages of

CuO and Cu<sub>2</sub>O in as-synthesized CuO/Cu<sub>2</sub>O samples were calculated by the relative intensities diffraction between (002) planes of CuO and (111) plane of Cu<sub>2</sub>O in Eq. (2) as below [23, 24]:

$$\varphi (Cu_2O) = I_{(111)}Cu_2O / [I_{(111)}Cu_2O + I_{(002)}CuO]$$
(2)

The volume fraction of CuO and Cu<sub>2</sub>O in the as-synthesized CuO/Cu<sub>2</sub>O samples was presented in Table 1. The particle sizes of CuO and Cu<sub>2</sub>O in samples were determined by using the Scherrer equation [25-28]. The crystallite size (D) of CuO and Cu<sub>2</sub>O was calculated from the diffraction peaks corresponding to the (002) plane of CuO and the (111) plane of Cu<sub>2</sub>O. The results are summarized in Table 1.



Fig. 1. XRD patterns of as-prepared CuO/Cu<sub>2</sub>O samples prepared via ultrasonic method.

Samples	Percent phases (%)		Particle sizes (nm)	
	CuO	Cu <sub>2</sub> O	CuO	Cu <sub>2</sub> O
C1	41.13	58.87	16.22	27.80
C2	25.32	74.68	17.86	33.58
C3	23.22	76.78	20.37	24.42
C4	22.27	77.73	21.43	28.58
C5	14.68	85.32	26.96	27.18

Table 1. Percent phases and particle sizes of as-prepared CuO/Cu<sub>2</sub>O samples.

Scanning electron microspore (SEM) analysis was conducted to study the morphologies of as-synthesized CuO/Cu<sub>2</sub>O samples prepared with varying amounts of NaBH<sub>4</sub>. The SEM images of all as-synthesized CuO/Cu<sub>2</sub>O samples (Fig. 2) exhibit the irregular shapes and agglomerates nanoparticles with an average size ranging from 0.1-0.6  $\mu$ m. Especially, the as-synthesized CuO/Cu<sub>2</sub>O sample (C4) exhibits the loose agglomerated resemble nanoparticles and microparticles which is advantageous for photocatalytic activities. According to the previous reports., the loose agglomerated particles with a two-shaped structure demonstrate the higher photocatalytic activity when compared to agglomerated particles with a one-shaped structure. [12, 29, 30]. The average particle size of CuO/Cu<sub>2</sub>O was increased with increasing amount of NaBH<sub>4</sub> [31-33]. However, the

 $CuO/Cu_2O$  synthesized with 0.25 g of NaBH<sub>4</sub> (C5) exhibited extreme agglomeration of nanoparticles which decrease the photocatalytic activity [12, 32, 34].



Fig. 2. SEM images of CuO/Cu<sub>2</sub>O samples prepared with (a) 0.05, (b) 0.10, (c) 0.15, (d) 0.20, and (e) 0.25 g of NaBH<sub>4</sub> adding, respectively by ultrasonic method.



Fig. 3. (a) TEM image of as-prepared CuO nanoparticles/Cu<sub>2</sub>O microparticles (C4), (b) SAED pattern of CuO nanoparticles island and HRTEM images of (c) single CuO nanoparticle and (d) single Cu<sub>2</sub>O microparticle.

Transmission electron microscope (TEM) image of as-obtained CuO/Cu<sub>2</sub>O sample in present of 0.20 g NaBH<sub>4</sub> (Fig. 3a) was composed of uniform nanoparticles with size of 50-100 nm which supported on the surface of microparticles with size of 500-600 nm. The selected area electron diffraction (SAED) pattern of nanoparticles island shows the bright ring electron diffraction pattern which can be in indexed to the (-110), (002), (-112), (020), and (-220) planes of monoclinic CuO structure. The high-resolution transmission electron microscopy (HRTEM) images of individual CuO nanoparticle (Fig. 3c) and Cu<sub>2</sub>O microparticle (Fig. 3d) shows lattice spacing of 0.25 nm and 0.24 nm which are corresponded to (002) of monoclinic CuO phase (JCPDS no. 45-0937) and (111) planes of the cubic Cu<sub>2</sub>O structure (JCPDS no. 05-0667) [21, 22], confirming the CuO nanoparticles supported on the surface of Cu<sub>2</sub>O microparticles.



Fig. 4 (a) Full XPS survey scan at 0-1200 eV and high-resolution binding energy spectra of (b) Cu 2p at 925-965 eV and (c) O 1s at 524-538 eV in as-prepared CuO/Cu<sub>2</sub>O sample in present of 0.20 g NaBH<sub>4</sub> (C4) by ultrasonic method.

Fig. 4a shows the full X-ray photoelectron spectroscopy (XPS) survey scan in as-prepared  $CuO/Cu_2O$  sample in present of 0.20 g NaBH<sub>4</sub> (C4) which were mainly composed of Cu, O, and C elements in sample. Fig. 4b shows the asymmetric high resolution binding energy peak of Cu 2p which can be fitted into six peaks at 932.14, 933.85, and 935.55 eV for Cu  $2p_{3/2}$  core level and 952.29, 954.10, and 955.93 eV for Cu  $2p_{1/2}$  core level. The oxidation state of Cu<sup>2+</sup> ions in CuO shows the symmetric binding energies at 932.14 eV for Cu  $2p_{3/2}$  core level and 952.29 eV for Cu  $2p_{1/2}$  core level with spin-orbit separation of 20.15 eV [35, 36]. The oxidation state of Cu<sup>+</sup> ions in Cu<sub>2</sub>O shows the symmetric binding energies at 933.85 eV for Cu 2p<sub>3/2</sub> core level and 954.10 eV for Cu 2p<sub>1/2</sub> core level with spin-orbit separation of 20.25 eV [35, 36]. However, the symmetric binding energies of Cu 2p<sub>3/2</sub> located at 935.55 eV and Cu 2p<sub>1/2</sub> peaks located at 955.93 eV were assigned to the satellite peaks form multiple excitations in  $2p^{0}3d^{9}$  configuration of  $Cu^{2+}$  in the CuO phase [36, 37]. The asymmetric binding energies of O 1s (Fig. 4c) can be deconvoluted by Gaussian analysis into four symmetric binding energies peaks located at 528.58, 530.15, 531.70, and 532.98 eV. The symmetric binding energies peaks of O 1s core level located at 528.58 and 530.15 eV can be defined as the Cu-O bonding in CuO and Cu<sub>2</sub>O lattices while the peak located at 531.70 and 532.98 eV can be attributed to adsorbed  $O_2$  and  $OH^2$  on the surface of as-prepared CuO/Cu<sub>2</sub>O samples surface [21, 38].

Fig. 5a shows the UV–Vis diffuse reflectance spectroscopy (DRS) spectra of as-synthesized CuO/Cu<sub>2</sub>O samples with the difference amounts of NaBH<sub>4</sub>. All samples exhibit strong absorption in the UV–Vis region, confirming their excellent light-harvesting capability and suggesting their suitability as visible-light-driven photocatalysts. The  $E_g$  of the CuO/Cu<sub>2</sub>O samples were estimated using the Kubelka–Munk function, allowing for a comparative analysis of the effect of NaBH<sub>4</sub> concentration on the optical properties of the photocatalysts [39, 40]. Fig. 5b shows the plots of

 $(\alpha hv)^2$  versus hv of the as-synthesized CuO/Cu<sub>2</sub>O samples with the difference amount of NaBH<sub>4</sub> samples [12, 37, 41]. The E<sub>g</sub> of as-synthesized C1 sample at 2.41 eV was shifted to 2.25 eV for as-synthesized C5 sample, indicating that the E<sub>g</sub> of as-synthesized CuO/Cu<sub>2</sub>O samples was decreased with increasing the phase percentage of Cu<sub>2</sub>O in samples.



Fig. 5. (a) UV-Vis DRS spectra and (b)  $E_g$  form Kubelka-Munk method of as-synthesized CuO/Cu<sub>2</sub>O samples with the difference of amount NaBH<sub>4</sub> samples.

Fig. 6a presents the RhB degradation under visible light irradiation using CuO/Cu<sub>2</sub>O samples synthesized at varying NaBH4 amounts. The pure RhB solution without photocatalyst under visible light irradiation as control experiment presents non-photolysis under visible light irradiation [42, 43]. Comparing to CuO/Cu<sub>2</sub>O samples, the photocatalytic efficiencies of RhB degradation over the as-synthesized CuO/Cu<sub>2</sub>O samples with the difference of amount NaBH<sub>4</sub> samples were 40.72%, 55.01%, 71.50%, 89.23% and 61.17%, for C1, C2, C3, C4, and C5 samples, respectively. Among them, the photocatalytic activity of CuO/Cu<sub>2</sub>O sample with 0.20 g NaBH<sub>4</sub> was the highest owing to the effectively facilitates the separate rate of photogenerated charge pairs. The photocatalytic activities of RhB degradation over as-synthesized CuO/Cu<sub>2</sub>O sample were increased with increasing the percent phase of Cu<sub>2</sub>O form 40.72% for C1 sample to 89.23% for C4 sample [34, 44]. According to the previous report, F.T. Joorabi et. al reported that the heterostructure CuO/Cu<sub>2</sub>O samples show the excellent photodegradation of methylene blue (MB) of 90% and methyl orange (MO) of 60% within 240 min due to the creation of hybrid CuO-Cu<sub>2</sub>O heterojunction, suppressing the recombination rate of photogeneated charge pairs [22]. However, the photocatalytic activities of RhB degradation over as-synthesized CuO/Cu<sub>2</sub>O sample decrease with increasing the percent phase of Cu<sub>2</sub>O to 85.32% for C5 sample because it may act as charge carrier recombination centers, decreasing photocatalytic performance. Fig. 7 shows the photoluminescent (PL) spectra of asprepared CuO/Cu<sub>2</sub>O samples prepared by ultrasonic method. It was observed that the intensity of PL spectrum of C4 exhibits the higher PL than other samples, suggesting that the highest electronhole pairs production and enhance the photocatalytic performance [22, 44, 45]. The kinetic photocatalytic degradation of RhB in present of all photocatalyst were calculated on the Langmuir-Hinstelwood model as shown in Fig. 6b [33, 46]. It shows a good linear relationship between  $\ln(C_0/C_1)$  of RhB versus reaction time for all heterostructure CuO/Cu<sub>2</sub>O samples with R<sup>2</sup> > 0.9, suggesting that photocatalytic degradation of RhB over photocatalysts was the first-order reaction [20, 47, 48]. The kinetic rate of photocatalytic degradation of RhB in present of as-prepared CuO/Cu<sub>2</sub>O photocatalyst were 1.62 x 10<sup>-3</sup>, 2.38 x 10<sup>-3</sup>, 3.94 x 10<sup>-3</sup>, 7.06 x 10<sup>-3</sup>, and 2.87 x 10<sup>-3</sup> min<sup>-1</sup> for C1, C2, C3, C4, and C5 samples, respectively. The kinetic rate of C4 sample is the highest, indicating that the C4 sample is the excellent photocatalysis.



Fig. 6. (a) Photodegradation efficiencies and (b) Langmuir-Hinstelwood model of RhB degradation using as-prepared CuO/Cu<sub>2</sub>O photocatalyst.

To investigate the role of active species in the photocatalytic process, the scavenger reagents including isopropanol (IPA) for  $^{\circ}OH$  trapping, 1,4-benzoquinone (BQ) for  $^{\circ}O_2^{-}$  trapping, and sodium oxalate (Na<sub>2</sub>C<sub>2</sub>O<sub>4</sub>) for h<sup>+</sup> trapping were added in RhB degradation over C4 as shown in Fig. 8a [33, 38, 49]. The photocatalytic efficiency of RhB degradation was obviously inhibited with the addition of IPA, demonstrating that the  $^{\circ}OH$  played the main active species for RhB degradation in present of C4 under visible light irradiation. In addition, Fig. 8b shows the cyclic photocatalytic performances of reused C4 sample after five recycles times which decrease to 83.87% after being reused five times, indicating that the C4 sample shows the high stability and reusability in practical photocatalytic applications [36, 49, 50].



Fig. 7. PL spectra of the  $CuO/Cu_2O$  samples prepared with the difference of amount NaBH<sub>4</sub> by ultrasonic method.



*Fig. 8. (a)* Scavenger testing and (b) cyclic photodegradation of RhB in present of as-prepared CuO/Cu<sub>2</sub>O sample (C4).

Fig. 9a illustrates the photoreduction performance of Cr(VI) under visible light irradiation using as-prepared CuO/Cu<sub>2</sub>O samples synthesized at different amounts of NaBH<sub>4</sub>. The pure Cr(VI) solution without a photocatalyst exhibited the no photoreduction under visible light irradiation [41, 51]. It was observed that the photoreduction efficiencies of Cr(VI) over the as-synthesized CuO/Cu<sub>2</sub>O samples with the difference amount of NaBH<sub>4</sub> were 23.60%, 50.12%, 55.06%, 72.81% and 30.12%, for the C1, C2, C3, C4, and C5 samples, respectively. The photocatalytic reduction kinetics of Cr(VI) in presence of all photocatalysts were calculated on the Langmuir-Hinstelwood model, as shown in Fig. 9b [34, 46]. It shows the linear curve plot of  $\ln(C_0/C_t)$  versus irradiated time (t) of Cr(VI) reduction with  $R^2 > 0.9$  was observed for all CuO/Cu<sub>2</sub>O samples under visible light irradiation, indicating that the photoreduction of Cr(VI) over CuO/Cu<sub>2</sub>O samples followed pseudofirst-order kinetic reaction [34, 46]. The kinetic rate of photoreduction efficiencies of Cr(VI) over CuO/Cu<sub>2</sub>O samples were 7.32 x 10<sup>-4</sup>, 1.91 x 10<sup>-3</sup>, 1.29 x 10<sup>-3</sup>, 3.664 x 10<sup>-3</sup>, and 1.14 x 10<sup>-3</sup> min<sup>-1</sup> for 0.05, 0.10, 0.15, 0.20, and 0.25 g of NaBH<sub>4</sub> adding, respectively. Among these, the C4 sample exhibited the highest photocatalytic reduction efficiency. This enhanced performance is attributed to the effective separation and transfer of photogenerated charge carrier pairs at the CuO-Cu<sub>2</sub>O heterojunction interface and its superior visible light absorption capability [47, 52]. Therefore, the C4 heterostructured CuO/Cu<sub>2</sub>O sample demonstrated the promising visible-light-driven photooxidation and photoreduction activities.



Fig. 9 (a) Photoreduction efficiencies and (b) Langmuir-Hinstelwood model of Cr(VI) using as-prepared CuO/Cu<sub>2</sub>O photocatalyst.

Fig. 10 shows the proposed schematic of the photocatalytic mechanism for the as-prepared CuO/Cu<sub>2</sub>O heterojunction. The CuO as n-type semiconductor and Cu<sub>2</sub>O as p-type semiconductor were created the internal electric filed at p-n heterojunction which accelerate the photogenerated carrier pairs migration between the CuO and Cu<sub>2</sub>O as photocatalysts unit the Fermi level equilibrium, suppressing the recombination of photo-induced electron-hole pairs [15, 16, 53, 54]. First, the higher photon energies than the band gaps of CuO and Cu<sub>2</sub>O were illuminated on the CuO and Cu<sub>2</sub>O surfaces. The photo-induced electrons were excited in the conduction band (CB) on the CuO and Cu<sub>2</sub>O while the photo-induced holes were created in the valance band (VB) on the CuO and Cu<sub>2</sub>O. Second, the photo-induced electrons were easily moved from the CB of Cu<sub>2</sub>O to the CB of CuO due to the potential of the conduction band ( $E_{CB}$ ) of Cu<sub>2</sub>O ( $E_{CB}$  Cu<sub>2</sub>O = -1.83 eV [55]) is negative than  $E_{CB}$  of  $Cu_2O$  ( $E_{CB}$  CuO = -0.70 eV [55]). At the same time, the photo-induced holes were moved from VB of CuO to the VB of Cu<sub>2</sub>O due to the potential of the valence band ( $E_{VB}$ ) of CuO ( $E_{VB}$  CuO = 0.88 eV [55]) is positive than  $E_{CB}$  of Cu<sub>2</sub>O ( $E_{VB}$  Cu<sub>2</sub>O = 0.64 eV [55]). Third, the photo-induced electrons in the CB of CuO and photo-induced holes in the VB of Cu<sub>2</sub>O were reacted with absorbed oxygen (O<sub>2</sub>) and water (H<sub>2</sub>O) molecules which causes the formation of  ${}^{\bullet}O_{2}^{-}$  and  ${}^{\bullet}OH$ radicals to degrade the dye molecules [15, 16, 54, 55]. The presence of optimal group phase ratio of CuO and Cu<sub>2</sub>O in this research is crucial for the promotes effective separation of electrons and holes for achieving high photocatalytic activities. The proportion of CuO:Cu<sub>2</sub>O is not suitable which it may act as charge carrier recombination centers, decreasing the photocatalytic activities [16, 50]. Furthermore, the grain size of CuO/Cu<sub>2</sub>O composites can also impact the behavior of charge carrier, enhancing the photocatalytic reaction.



Fig. 10. The photocatalytic mechanism for the as-prepared CuO/Cu<sub>2</sub>O heterojunction.

### 4. Conclusions

In this research, the heterojunction  $CuO/Cu_2O$  sample was prepared successfully via ultrasonic method. The heterojunction  $CuO/Cu_2O$  sample showed the excellent photodegradation of RhB and photoreduction of Cr(VI) under visible light irradiation. Finally, the heterojunction  $CuO/Cu_2O$  (C4) sample showed the highly stability for reusable in practice photocatalytic application.

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