NTA2022

2nd International Conference on
Nanotechnology: Theory and Applications,
Cairo, 19 – 21 Dec., 2022

Ref. 065

Novel Solar simulated photocatalytic heterolysis of pharmaceutical wastewater via slag nanocomposite immobilization: Optimization using response surface methodology

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KEYWORDS

Slag; Nanocomposite; Response surface methodology; Photo-Fenton degradation; pharmaceutical wastewater; Optimization analysis

SHORT SUMMARY

This study converted slag from the steelmaking industry into a Fe_2O_3-rich nanocomposite using solvothermal technique for photo-Fenton degradation of pharmaceutical wastewater in an immobilized mode. The nanocomposite was characterized using XRF, SEM, FTIR, XRD, and UV–Vis spectrometer. The XRF analysis result revealed a significant increase in the weight percent of Fe_2O_3 and SiO_2, with a decrease in CaO content. The SEM images revealed the spherical and heterogeneous nature of the nanocomposite in shape and structure, while the FTIR confirms the increase in the vibration band of Si-O-Si and Fe-O with a reduction in the wide stretch mode of Ca-O. The XRD result illustrated the crystalline peak of Fe_2O_3 with a nanoparticle crystal size of 15.17 nm. The slag nanocomposite was used for photo-Fenton degradation of Paracetamol. The optimum operating parameters were obtained using response surface methodology at an R2 value of 0.99 and p-value < 0.05. The degradation efficiency obtained at the optimum value was 96.96%. The degradation efficiency of the 5th repeated cycle of the immobilized nanocomposite was 77.89%. The degradation mechanism revealed that OH• radical was the major species of the degradation process. This work showed that slag nanocomposite might be effectively used for pharmaceutical wastewater treatment.

EXTENDED ABSTRACT

The steelmaking sector produces a large amount of waste. Slag is a solid waste of the steelmaking process. The worldwide output of steel waste such as slag surpasses fifty million tons per year. Steel slag is mostly composed of TiO_2, Fe_2O_3, SiO_2, Al_2O_3, MnO, P_2O_5, MgO, and CaO. The storing of this slag involves the usage of a large amount of land and results in severe environmental contamination[1]. Using this waste as a catalyst will be of good advantage. Moreover, wastewater from the pharmaceutical sector has recently expanded due to the rising demand for its many goods, which are used to treat animals and humans Pharmaceutical industrial wastewater includes several bio-recalcitrant organics that are challenging for traditional wastewater treatment methods to eliminate [2]. Advance oxidation process such as photo-Fenton have been proven to be the best to solve this problem. Nevertheless most of the nano catalyst used in this process involves mixing of expensive chemical.

Numerous water treatment applications have made use of steel slag that has been ground into a nanocomposite. However, there are limits to the amount that may be collected and reused [3]. In

addition, the issue of collection may be resolved by immobilizing the supporting plate with a catalyst.

For the first time, synthesized nanocomposites steel slag (NCSS) was applied for photo-Fenton degradation of paracetamol (PC) in immobilized mode. Operational optimization was done using response surface methodology (RSM). Reusability of the nanocomposite was analyzed. Scavenger analysis was tested, and the degradation pathway was generated using LCMS.

Materials and Methods

Slag from Egypt's Ezz steel was examined. The nanocomposite was synthesis by solvothermal preparation technique. The nanocomposite was immobile on aluminum plate. The test was done base on the matrix parameters in Table 1. Under a novel photo reactor in Fig 1.

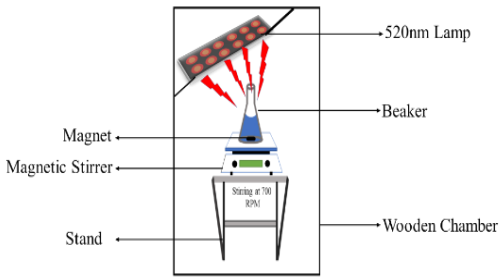

Fig 1 . Simulated solar novel photo reactor

Characterization

The nanocomposite was characterized using XRF, SEM, FTIR, XRD, and UV–Vis spectrometer

Experimental Design

RSM of the matrix in Table 1, was used.

Table 1 Factors and their matrix

Factors		Levels		
Name	unit	Lowest value -1	Median value 0	Highest Value +1
Time	mins	10	35	60
PC	ppm	10	20	30
NCSS dose	mg/L	10	35	60

Result and Discussion

FTIR and TEM

As shown in Fig 2 (a) the XRF result indicated the elemental and chemical composition of a raw slag and NCSS with F_2O_3 being the largest constituent of the nanocomposite with 49.56% by weight.

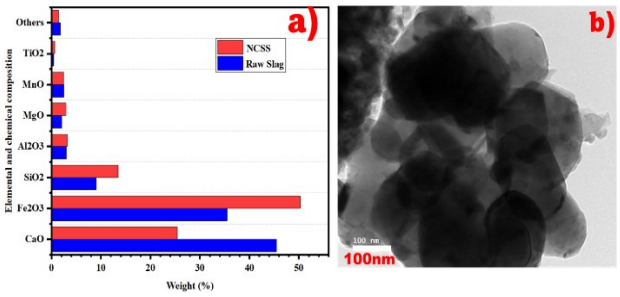

Fig 2. (a) XRF and (b) TEM images of NCSS

Moreover, the TEM image shows the distinct distribution of the element in the nanocomposite with the dark side corresponding to the iron content [3].

Application of NCSS for degradation of paracetamol

The result has indicated in Fig. 3 shown a 96.96% degradation of PC using NCSS.

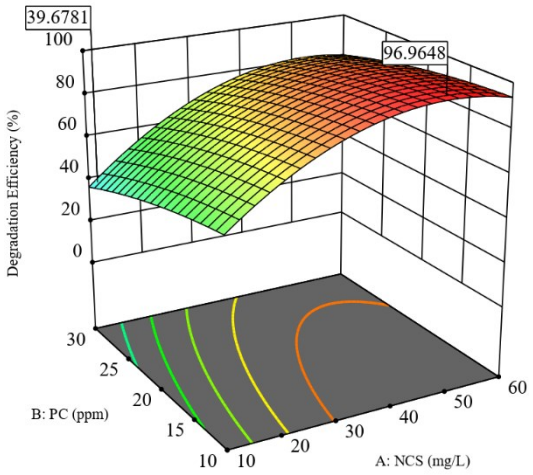

Fig 3. 3D surface degradation of PC using NCSS

Conclusion

The prepared NCSS shows a good degradation of pharmaceutical waste water (Paracetamol).

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