RESEARCH PAPER

Green Synthesis of C@Fe₃O₄@Ag Nanocomposites: Coating of Silver Nanoparticles on the Carbon Template/Magnetite as a Catalyst for Conversion of Toxic Carbon Monoxide to Carbon Dioxide

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ABSTRACT

Carbon nano-templates were prepared from walnut shell calcination, then magnetite (Fe_3O_4) nanoparticles were coated on the carbon nano-templates. On the other hand silver (Ag) nanostructures were synthesized via a facile green precipitation method applying lactose as green capping agent in solvent of water and were coated on the C@Fe_3O_4 templates. Finally toxic carbon monoxide gas was purged from carbon/magnetite/Ag nanocomposites. The phase of prepared products were examined by X-ray diffraction pattern (XRD), band gap and optical were measured by UV–visible absorption spectroscopy, the bonds using the (FTIR) spectrometry and morphology via scanning electron microscopy (SEM). The oxidation behaviour of C@Fe_3O_4@Ag nanocomposites was evaluated using the conversion of carbon monoxide to carbon dioxide. The results introduce a relatively easy prepared nanocomposite for solving problem of fatal carbon monoxide.

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INTRODUCTION

At present, understanding the scientific properties of environmental pollution from different perspectives is economically very valuable. Much research has been done to find a method using photocatalysis to decompose [1–3]. Ag known to have excellent photocatalytic activity in the decomposition and purification of various contaminating components [4–7]. Silver one of royal metals, has optimum conditions for oxidation reactions. It has been used to produce a highly efficient photocatalyst with an appropriate band [8]. Besides its large magnetic anisotropy and moderate saturation magnetization, it has remarkable chemical stability and mechanical hardness [9–12]. They have excellent mechanical, chemical, and thermal properties with water resistant function [13–17]. This study describes the synthesis and characterization of nanosized silver particles using precipitation method. investigated the formation of monodispersed nanoparticles in transition. The prepared nanoparticles were compared in the same environment in terms of morphology and structure properties.

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MATERIALS AND METHODS

$AgNO_3$, $Fe(NO_3)_3$ $9H_2O$, $FeCl_2$ $6H_2O$, lactose, tri sodium citrate, $NaBH_4$ were purchased from Merck or Aldrich and all the chemicals were used as received without further purifications. A multiwave ultrasonic generator (Bandeline MS 73), equipped with a converter/transducer and titanium oscillator, operating at 20 kHz with a maximum power output of 150 W was used for the ultrasonic irradiation.. XRD patterns were recorded by a Philips, X-ray diffractometer using Ni-filtered CuK_{α} radiation. SEM images were obtained using a LEO instrument model 1455VP. Prior to taking images, the samples were coated by a very thin layer of Pt (using a BAL-TEC SCD 005 sputter coater) to make the sample surface conductor and prevent charge accumulation, and obtaining a better contrast.

Synthesis of carbon/magnetite/silver nanoparticles

For preparation of carbon nano templates, walnut shell were calcined at 350ºC. After that the black powders were dispersed in water under ultrasonic irradiation 150W, 60 min. Iron nitrate and iron chloride were added and dissolved in the solvent and under nitrogen atmosphere ammonia was added. Then silver nitrate was added to the $C@Fe_3O_4$ dispersion. After 60 min mixing under heater-stirrer lactose and ammonia ere added for reduction of silver ions to silver metals. A brown precipitate was then centrifuged and rinsed with distilled water. Finally obtained precipitate was dried at 85°C and the press was done for preparation of tubular catalyst. The schematic diagram for experimental setup for nanoparticle and nanocomposite preparation used in the precipitation procedure (Fig. 1).

RESULTS AND DISCUSSION

For characterization of the phase and

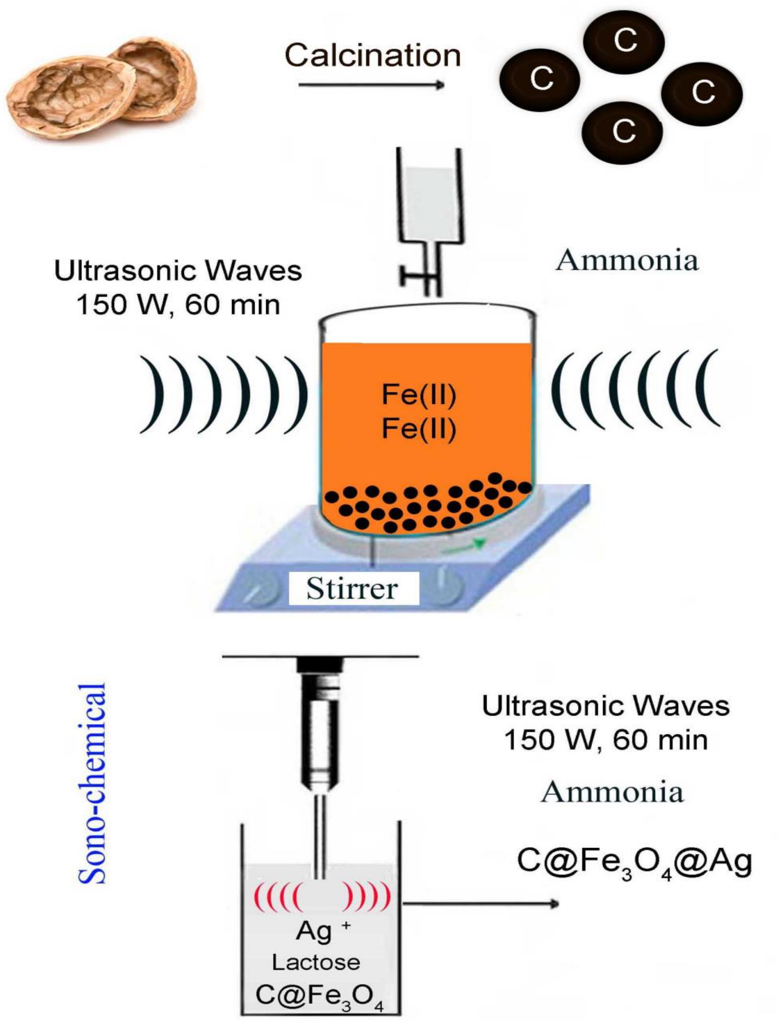

Fig. 1. Schematic of preparation $C@Fe_3O_4@Ag$ nanocomposites

crystallization X-ray diffraction pattern was used (Fig. 2). The XRD pattern of Fe_3O_4 reveals the typical diffraction pattern of pure cubic phase (JCPDS No.: 75-0033) with Fd-3m space group which is consistent with magnetite ferrite.

The crystalline sizes from Scherrer equation, D_c=Kλ/βCosθ, was calculated, where β is the width of the observed diffraction peak at its half maximum intensity (FWHM), K is the shape factor, which takes a value of about 0.9, and λ is the X-ray wavelength (CuK_α radiation, equals to 0.154 nm).The average crystalline size for Fe_3O_4 and Ag nanoparticles were found to be about 10 and 15nm respectively [18-23].

Scanning electron microscopy was employed for estimation of morphology and particle size of

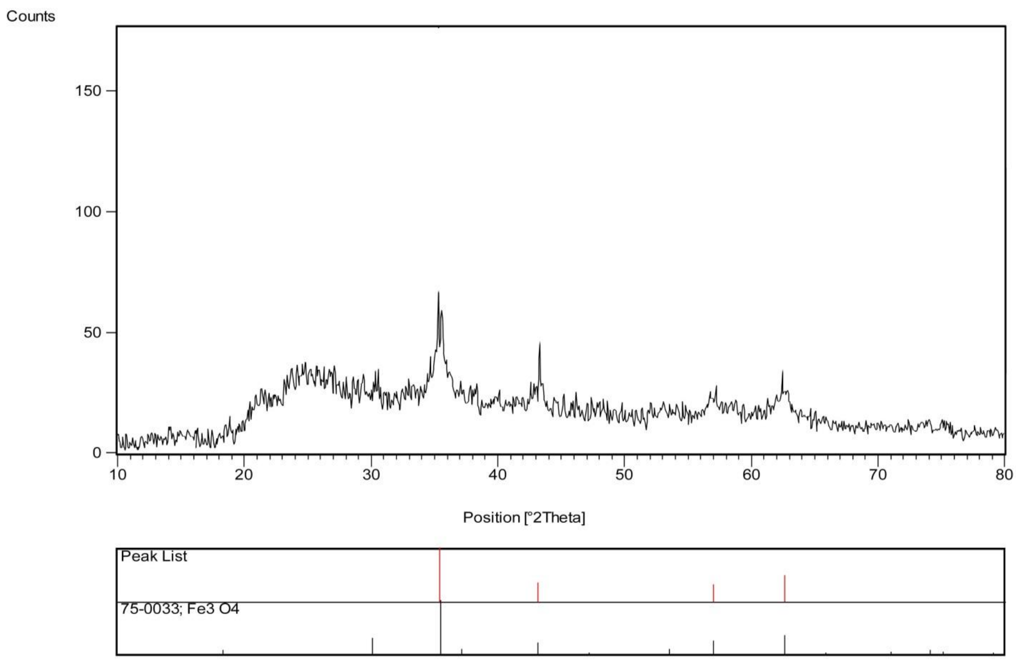

Fig. 2.XRD pattern of Fe_3O_4 nanoparticles

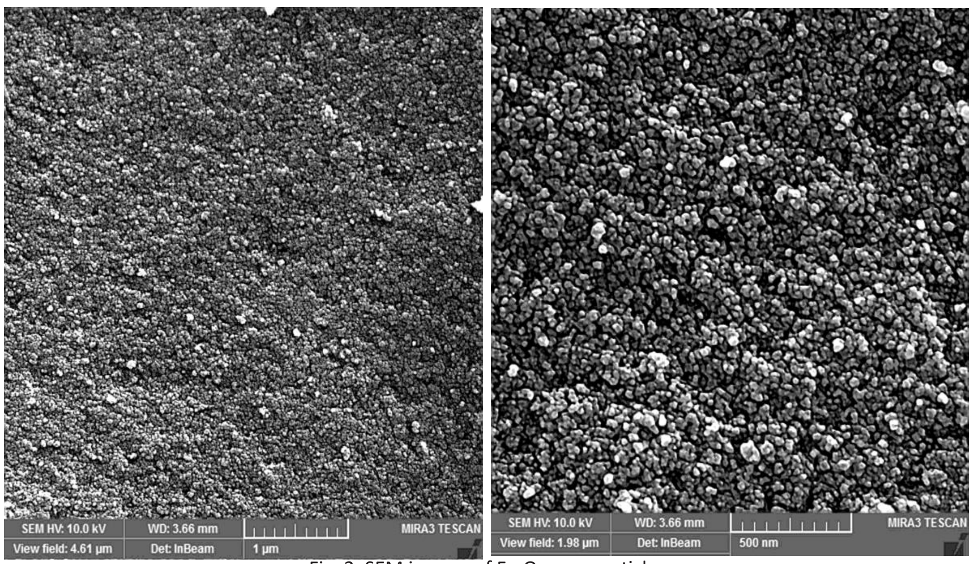

Fig. 3. SEM images of Fe_3O_4 nanoparticles

the products. SEM image of Fe_3O_4 nanoparticle are shown in Fig. 3. The results confirm that particle size is about 20 nm . SEM image of the C@Fe_3O_4 nanoparticles is illustrated in Fig. 4. According to scanning electron microscopy images the average particle size is found to be around 90 nm. Figs. 5. shows SEM image of the C@Fe_3O_4@ Ag nanoparticles, image confirms growth stage overcome to nucleation stage, nanoparticles on the star-like matrix was prepared.

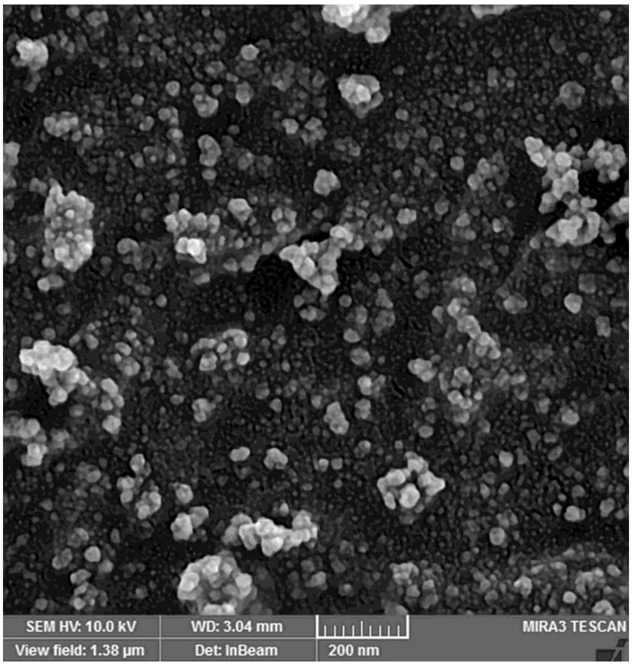

Fig. 4. SEM image of C@Fe_3O_4 nanocomposite

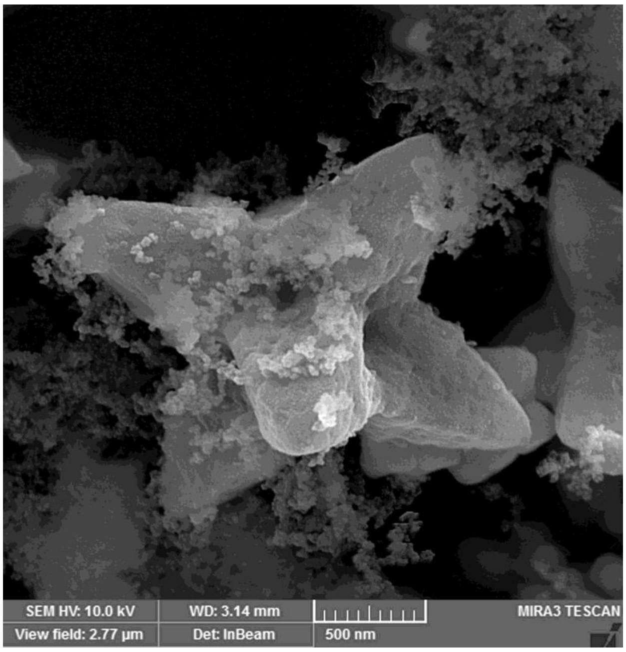

Fig. 5. SEM image of C@Fe_3O_4@Ag nanocomposite

Fig. 6 shows magnetic property of magnetite was studied using VSM instrument. The result indicates that, the sample exhibit super paramagnetic property. A saturation magnetization around 84 emu/g, and coercivity about zero Oe have been achieved. Magnetization curve of C@Fe_3O_4 that also exhibits also ferromagnetic behaviour with a coercivity of about 200 Oe and saturation magnetization of 60 emu/g (Fig. 7). VSM curve of C@Fe_3O_4@Ag nanocomposites after CO interaction is shown in Fig. 8. It depicts ferromagnetic behaviour (coercivity around 250 Oe, saturation magnetization: 60 emu/g). The magnetic property of the prepared nanocomposites is an essential

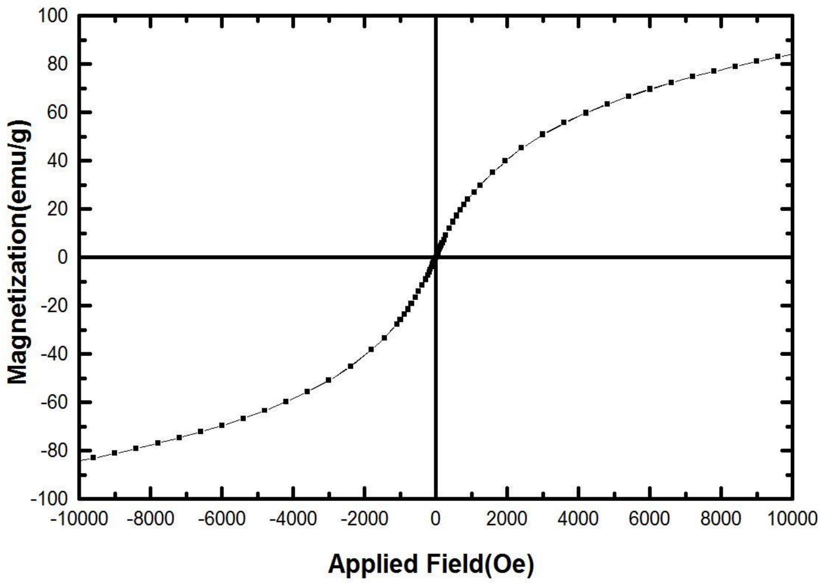

Fig. 6. VSM graph of Fe_3O_4 nanoparticles

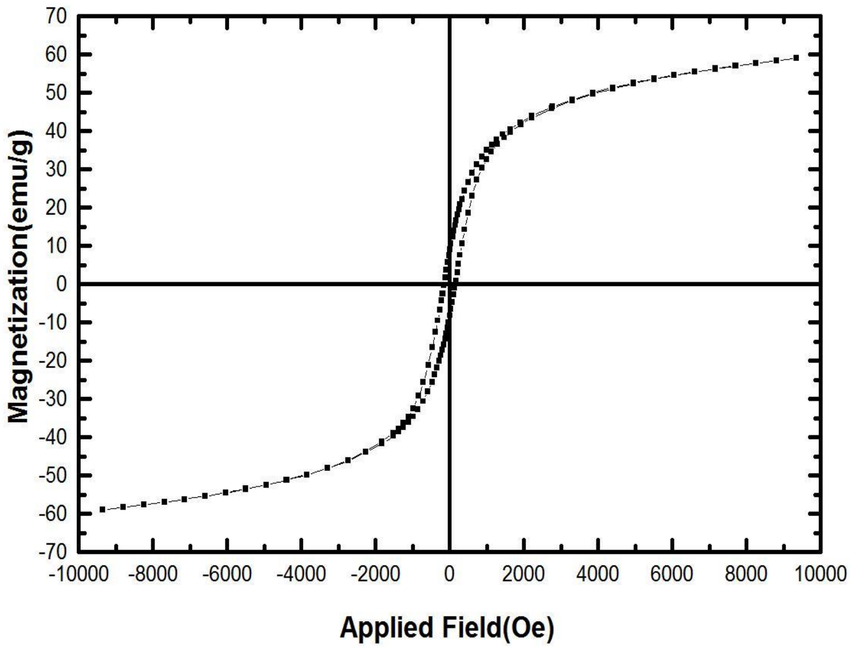

Fig. 7. VSM curve of C@Fe_3O_4 nanocomposites

characteristic of a heterogeneous nanocomposite since materials with this magnetic behaviour have low tendency in inter-particles agglomeration caused by dipole-dipole interaction in comparison

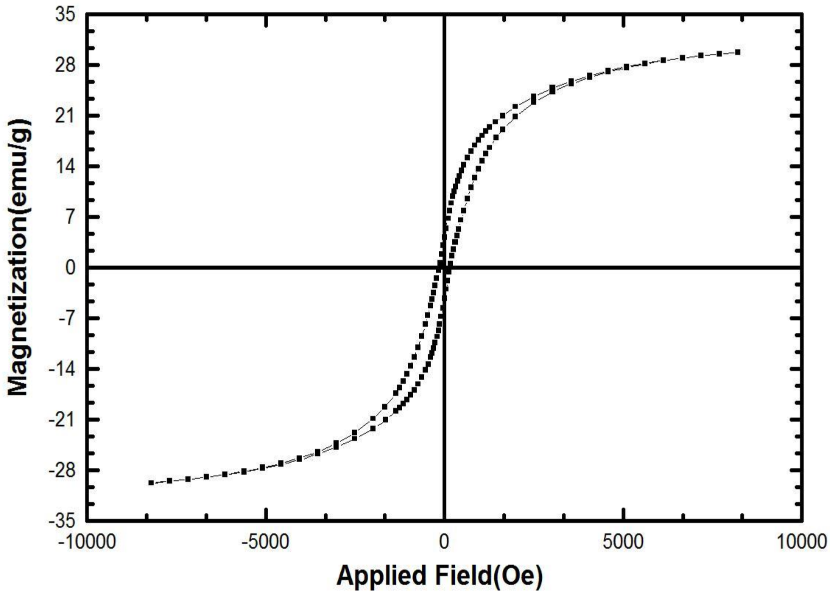

Fig. 8. VSM curve of $C@Fe_3O_4@Ag$ nanocomposites after CO interaction

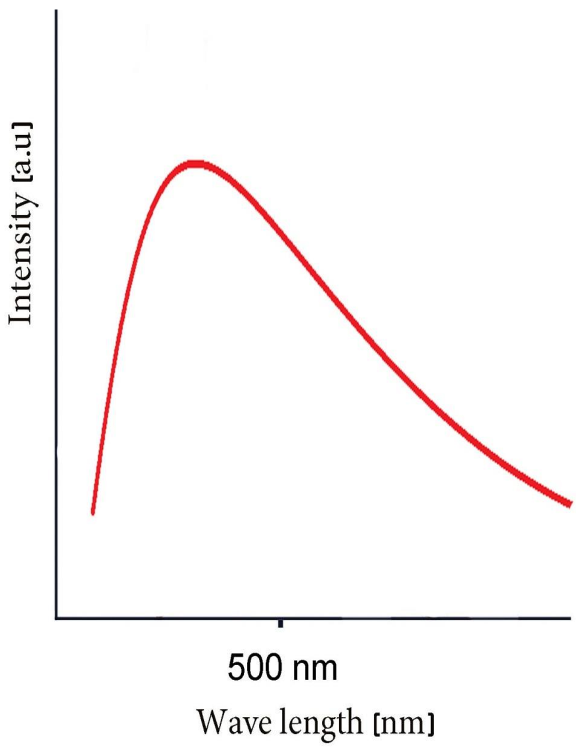

Fig. 9. UV–Visible absorption of $C@Fe_3O_4@Ag$ nanocomposites

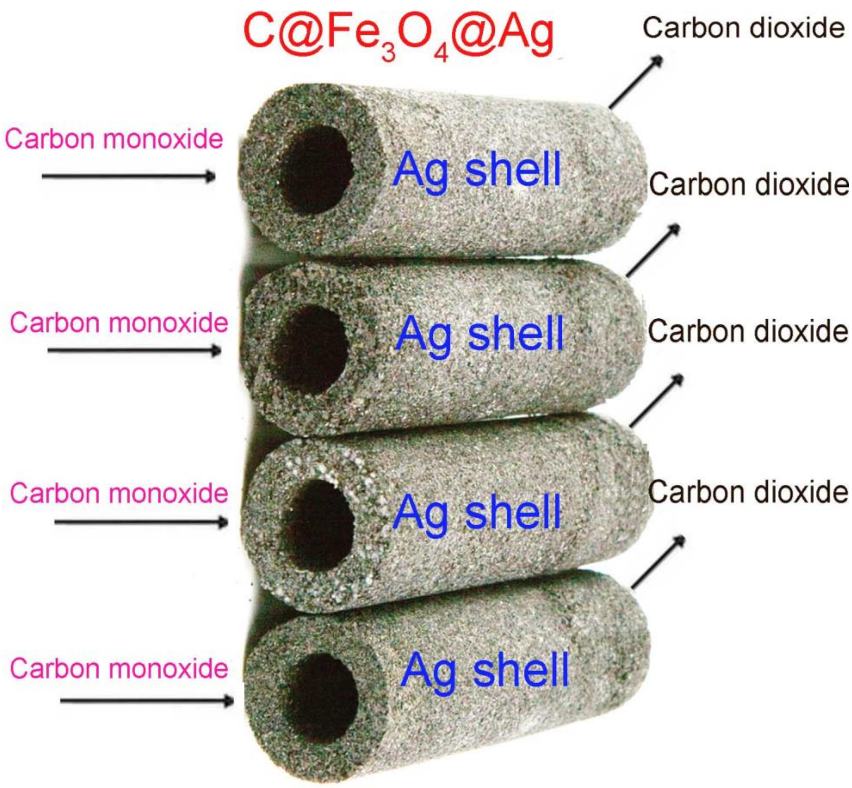

Fig. 10. Catalyst reaction of C@Fe_3O_4@Ag nanocomposites for conversion of carbon monoxide to carbon monoxide

with ferromagnetic nanocomposites.

UV-vis absorption spectrum of C@Fe_3O_4@Ag nanocomposites is illustrated in Fig. 9, a broad peak around 480nm is related to nano structures levels. Catalyst reaction of C@Fe_3O_4@Ag nanocomposites for conversion of carbon monoxide to carbon monoxide schematically is depicted in Fig. 10. 400 ppm of carbon monoxide gas were purged under tubular carbon/magnetite/silver nano-catalyst. Two gas sensor/detectors were applied before and after tubular nanocomposite catalyst. After transmission of gas from tube concentration of carbon monoxide reduce to under 25ppm.

CONCLUSION

In this work, C@Fe_3O_4@Ag nanocomposites were prepared via a simple chemical two steps route. The crystalline structure, surface functional group, and optical properties of as-obtained samples were characterized via X-ray diffraction pattern (XRD), FTIR spectrometry , and UV–visible absorption spectroscopy, respectively. The morphological properties of products were investigated via scanning electron microscopy (SEM). Then, the prepared C@Fe_3O_4@Ag nanocomposites were applied for the oxidation of carbon monoxide to carbon dioxide. The findings confirmed prepared C@Fe_3O_4@Ag nanocomposites can act as a good oxidation agent for the conversion of carbon monoxide to carbon dioxide.

ACKNOWLEDGEMENTS

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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