Synthesis of cobalt ferrite via coprecipitation method: a mini review

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Abstract

Cobalt ferrite is a magnetic material. Ferrites can be used in electronics, biomedical applications to name a few. Several methods are developed to prepare these ferrites. Coprecipitation is one of the commonly used methods. Several research groups synthesised cobalt ferrite using nitrate precursors in aqueous medium. The value of pH and temperature played an important role.

Keywords: Magnetic material, ferrite, coprecipitation.

Introduction

Ferrites are magnetic materials. The general applications of ferrites are as follows:

- These are usually observed as a lump in the cable of computers, known as bead. It helps to restrict huge frequency electrical noise.
- Ferrite also plays an important role as a radar-absorbing material or in the coatings of aircrafts and for electromagnetic compatibility measurements.
- Ferrite magnet commonly radio magnet used in loudspeaker.
- Ferrites are used in microwave equipment that can be used in radar, aircraft and satellite guidance and in space communication systems.

Due to these applications efforts are made to synthesise this material. There are several methods using which cobalt ferrite nanoparticles can be synthesised. Here, we have reviewed the synthesis of this material using coprecipitation method. As the name says, coprecipitation refers to a process of simultaneous precipitation of a normally soluble component with a macro-component from the same solution by the formation of mixed crystals. Synthesis of cobalt ferrite by different research group is summarised below.

2. Preparation of cobalt ferrite using coprecipitation method

Vinosha et al. used the following method:

Cobalt nitrate and ferric nitrate (Merck, pure analytical) were used. 0.1 M $CoNO_3$ and 0.2 M $FeNO_3$ were mixed with 100 ml of distilled water to form a clear solution. It was constantly stirred. NaOH was added dropwise with constant stirring to maintain the pH of reaction. Efforts were made to maintain the pH of the reaction mixture to 9. The mixture was then heated for 3 hours at 80 °C with constant stirring. The product

was obtained in the form a brown precipitate. It was then centrifuged. The resulting product was treated with distilled water for three times in order to wash it. It was also washed with ethanol twice to maintain a neutral pH. The precipitates were further dried up to 80 °C in an electric oven for about 24 hours. The product formed using the above method was calcined at 500 °C for 5 hours. Sample analysis suggested that the desired $CoFe_2O_4$ nanoparticles formed [1].

Shahjuee et al. used all the reagents from Merck Co. The chemicals were not purified in-house. Required amounts of $CoCl_2.6H_2O$ was mixed with appropriate amount of $FeCl_3.6H_2O$ and were dissolved in water to form an aqueous solution. Molar ratio of the Fe^{3+} to Co^{2+} as 2:1 was taken. The as such prepared solution was taken into a burette containing 2 ml hydrochloric acid. This mixture was added dropwise to 1.5 M NaOH solution into a reaction vessel. NaOH was used as precipitating agent. The mixture was then heated to 60°C to 90 °C. The reaction mixture was homogenised. The pH of the mixture was maintained to 12. Surfactant effect was studied by addition of an organic acid (oleic acid, 0.5 v/v%) into the reaction vessel. Precipitate was collected using a strong magnet. A strong magnet used to collect precipitates. Distilled water was used as washing agent of the reaction product. Washing process was repeated several times to achieve a neutral pH (i.e. pH = 7). Finally, in an electric oven was used to dry the precipitates for 2 hours at temperature maintained up to 100 °C [2].

Darwish et al. used several chemicals from Sigma Aldrich, St. Louis, MO, USA. Iron (III) chloride hexahydrate (8.1 g), iron (II) chloride tetrahydrate (3.97 g), cobalt (II) chloride hexahydrate (2.37 g) which is 3:2:1 molar ration respectively, were mixed with 50 mL of distilled water at room temperature and homogenised for about 15 minutes. The mixture heated to 60 °C for 5 minutes while stirring to obtain a homogeneous solution. The reactants were stirred vigorously. It was the treated with 30% ammonium hydroxide (20 ml). Ammonium hydroxide was added drop wise to induce the particle growth. The resultant reaction mixture was further stirred for 30 minutes at 60 °C with an aim to evaporate excess of ammonia when black coloured precipitates were obtained. The precipitate was washed several times with double distilled water to confirm the complete removal of ammonium salts followed by drying for ~24 hours when cobalt ferrites nanoparticles were formed [3].

Krishna et al. used cobaltous chloride and ferric chloride (Analytical grade) were used as source of cobalt and iron. Reagents were taken in two separate beakers with amount of 4 ml and 40 ml with molar ratios of $CoCl_2$ and $FeCl_3$ as 1:2 with distilled water respectively. It was then stirred the above two solutions separately with constant heating at 50 °C. These solutions were allowed to react at 50°C for half an hour. In another beaker 200 ml of 1M NaOH was prepared. The resulting reaction mixture was heated at 100 °C. The reaction mixture was then mixed drop wise (0.5 ml/sec) into NaOH with constant stirring. This resulted in the formation of a black precipitate. The precipitates formed washed three or four times with distilled water for complete removal of unreacted chlorides and with ethanol three times again to removes ions. The product was dried at room temperature in a vacuum desiccator to when the desired product was obtained [4].

Zhang et al. used $Fe(NO_3)_3.9H_2O$ (Analytical grade) and $Co(NO_3)_2$. $6H_2O$ (Analytical grade) were used as source of iron and cobalt. Aqueous solutions of the above said chemicals were treated with NaOH and heated when the desired product was obtained [5].

Sharifi et al. used all the reagents were purchased from Merck Co. Germany. In-house purification of chemicals was not carried out. 100 ml of 1.0 M $CoCl_2.6H_2O$ and 2.0 M $FeCl_3.6H_2O$ was prepared. It was then heated to a constant temperature of 60°C. The mixture was the added to the boiling solution of 0.63 M NaOH (1200 ml). It was stirred continuously. The temperature of the reaction mixture was increased to 85 °C for an hour. The product was collected using magnetic separation. It was then purified using distilled water and acetone. The process of washing was repeated several times [6].

Summary

Cobalt ferrite is magnetic in character. It has a wide range of application. Researchers widely because of it is a simple process and does not require very complex laboratory infrastructure. The completion of reaction did not require very high temperatures. Nitrates and chlorides are mainly used as starting materials for the reaction. Many research groups used magnets for the collection of nano particles.

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