The ۷th International Color & Coating Congress

۱۹-۲۱ December ۲۰۱۷

Amirkabir University of Technology, Tehran, Iran

The 7th International Color & Coating Congress (ICCC2017), 19-21 December 2017
Amirkabir University of Technology, Tehran, Iran

Solution Combustion synthesis of cobalt-doped zinc oxide Nano pigments

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Abstract

In this study, cobalt-doped ZnO Nano pigments were synthesized by combustion method, using glycine as fuel. Prepared powders were characterized by X-ray diffraction, vibration Sample Magnetometer and Uv-Visible. X-Ray diffraction patterns showed the formation of wurtzite single phase with secondary Co_3O_4 phases. In different fuel-to-oxidizing ratios, we saw different percentages of the secondary phases. The results of the magnetic studies showed that there is a ferromagnetic property in the synthesized Nano pigments in all three ratios of fuel to oxidizers. Using the spectrophotometer, the color properties of the samples prepared in three different ratios of fuel to oxidizing and in percentages (1-X= 0.06, 0.54, 1) of Cobalt Doped were characterized. As the amount of cobalt-doped increases in all three ratios of fuel to oxidizing the reflectance spectrum of the absorption band from the green to the blue direction was indicated.

Keywords: ***combustion- glycine- Nano pigment- synthesize- fuel.***

ICCC 2017

Amirkabir University of Technology
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as Oral Presentation
by

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Tehran,Iran
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Abstract

In this study, cobalt-doped ZnO Nano pigments were synthesized by combustion method, using glycine as fuel. Prepared powders were characterized by X-ray diffraction, vibration Sample Magnetometer and Uv-Visible. X-Ray diffraction patterns showed the formation of wurtzite single phase with secondary $Co_۳O_٤$ phases. In different fuel-to-oxidizing ratios, we saw different percentages of the secondary phases. The results of the magnetic studies showed that there is a ferromagnetic property in the synthesized Nano pigments in all three ratios of fuel to oxidizers. Using the spectrophotometer, the color properties of the samples prepared in three different ratios of fuel to oxidizing and in percentages (۱-X= ۰.۰٦, ۰.٥٤, ۱) of Cobalt Doped were characterized. As the amount of cobalt-doped increases in all three ratios of fuel to oxidizing the reflectance spectrum of the absorption band from the green to the blue direction was indicated.

Keywords: combustion- glycine- Nano pigment- synthesize- fuel

۱- Introduction

The study of transition metal ion doped in optical properties of metal oxide is of great importance. Accordingly lots of considerable attention has been given by researchers and scientists on transition metal ions doped ZnO Nano pigments. The wide band gap energy (Eg=۳.۳۷eV) and high exciton binding energy (٦۰ meV) at room temperature of ZnO nanoparticles makes them useful for optical technological application [۱-٤]. According to these, solution combustion synthesis method was used to produce Co doped ZnO Nano particles in this paper and the effect of fuel to oxidizer ratio (F/O) on some optical and physical properties was studied.

۲- Experimental

Zn $(NO_۳)_۲.٦H_۲O$, Co $(NO_۳)_۲.٦H_۲O$, $NH_۲CH_۲COOH$ (Glycine) and Distilled water Used without any additional purification. Nitrates are introduced as oxidizing agents (O) due to the release of oxygen while glycine was used as fuel (F) or reducing agent. After complete homogenization of the solution for ۲۰ minutes, temperature increased to ۳٦۰°C, a homogenous gel formed and the combustion process occurred and final Nano particles synthesized in less than ۱۰ min.

۳- Results and Discussion

According to the results of XRD in the ratio of F/O=۰.۷٥ the highest amount of secondary phase was observed. Since the combustion process requires fuel and oxygen to promote combustion, in the fuel / oxidation ratio of less than one (F/O=۰.۷٥), due to fuel shortages the combustion process is not completely oxidized. This can be a reason for the presence of further phases in this ratio of F/O. In the F/O = ۱, due to the complete combustion and higher temperature, the lowest amount of un-wanted phases were formed. Particle size calculations for various fuel ratios are given in tables (۱-۳). The calculations showed that the particle size variation in different ratios of fuel to oxidizing agent is in such way that: in the ratio of F/O=۰.۷٥ due to incomplete doping of cobalt ions and low combustion temperature, particles have lower particle size. Because doping of cobalt ions in the crystalline structure of ZnO decreases its growth, these conditions occurred more completely in the F/O=۱ ratio. However, in the ratio of F/O=۱.۲٥, due to the incomplete doping, higher reaction temperature and the length of the combustion process, the ZnO crystalline size increased. Magnetic results showed that in the F/O=۰.۷٥, the presence of ion impurity phases Cobalt, as well as coarse particles, caused a weak

ferromagnetic property. By increasing the ratio of the fuel to the oxidizing to ١ due to the presence of zinc cations and decrease in the particle size, the magnetic property of the Nano pigments increased. In F/O=١.٢٥ highest magnetic properties was observed, due to the presence of Cobalt. The color properties of the prepared specimens were evaluated in three ratios of different oxidizing fuel and in in percentages (١-X=٠.٠٦,٠.٥٤,١) of cobalt doped. In each of the three ratios of fuel to oxidizing, increasing the amount of cobalt-dop, due to a structural defect, the reflection spectrum of the absorption band from the blue to the green direction was indicated. The calculations of band gap energy and absorption wavelengths for the three oxidizing ratios are presented in Tables (٤-٦).

٤- Conclusion

In this study, $Co^{٢+}$ ions successfully doped in ZnO nanoparticle by combustion synthesis method. XRD results showed crystalline composition with the presence of a secondary phase of $Co_٣O_٤$. VSM results showed significant changes in the magnetic properties with impurity doping level. Band Gap energy was reduced due to the formation of the subtle layers as a result of the presence of defects in the structure.

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Table ١: The crystalline size in F/O=٠.٧٥

ratio of F/O	Conc.١-x mol	D (nm)
٠.٧٥	٠.٠٦	٢٢.٠٠٧٩
	٠.١٨	١٨.٢٤٣٤
	٠.٣٦	١٧.٥٥٠٦
	٠.٥٤	٢٧.١٨٦٢

Table ٢: The crystalline size in F/O=١

ratio of F/O	Conc.١-x mol	D (nm)
١	٠.٠٦	١٨.٢٤٣٢
	٠.١٨	١٧.١٧٢٧
	٠.٣٦	١٦/٩٠٨٥
	٠.٥٤	٢٤.٧٥٨٩

Table ٣: The crystalline size in F/O=١.٢٥

ratio of F/O	Conc.١-x mol	D (nm)
١.٢٥	٠.٠٦	٢٥.٦٧٥٩
	٠.١٨	٢٤.٣٢٤٥
	٠.٣٦	٢٥.٢٠٩٠
	٠.٥٤	٢٨.٨٨٥٤

Table ٤: The band gap energy and wavelength of Nano pigment in F/O=٠.٧٥

ratio of F/O	Conc.١-x (mol)	E_g (ev)	λ (nm)
٠.٧٥	٠.٠٦	٣.٤٦٥	٣٥٨
	٠.٥٤	٢.٧٨٨	٤٤٥
	١	٢.٧٢٦	٤٥٥

Table ٥: The band gap energy and wavelength of Nano pigment in F/O=١

ratio of F/O	Conc.١-x (mol)	E_g (ev)	λ (nm)
١	٠.٠٦	٣.٧٧٦	٣٥٥
	٠.٥٤	٣.٠٤٠	٤٠٨
	١	٢.٧٤٤	٤٥٢

Table ٦: The band gap energy and wavelength of Nano pigment in F/O=١.٢٥

ratio of F/O	Conc.١-x (mol)	E_g(ev)	λ (nm)
١.٢٥	٠.٠٦	٣.٤٧٥	٣٥٧
	٠.٥٤	٢.٦٩٧	٤٦٠
	١	٢.٦٦٨	٤٦٥

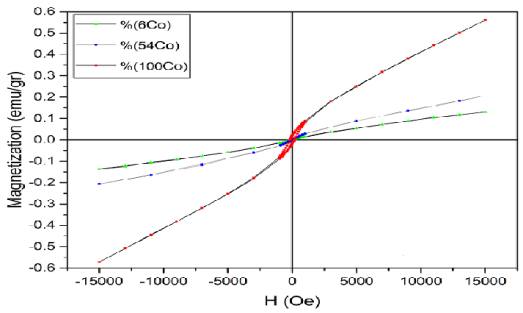

Figure ١: Magnetic behavior in F/O=٠.٧٥ and (١-x=٠.٠٦, ٠.٥٤, ١)

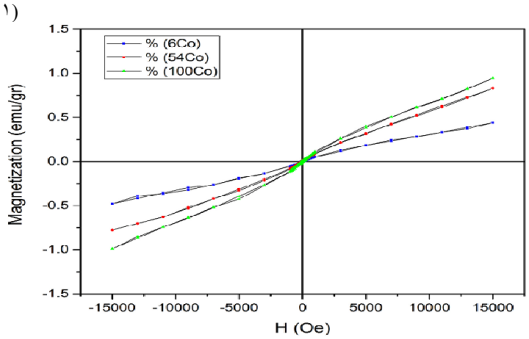

Figure ٢: Magnetic behavior in F/O=١ and (١-x=٠.٠٦, ٠.٥٤, ١)

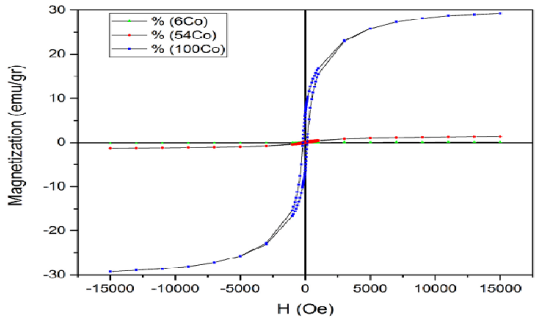

Figure ۳: Magnetic behavior in F/O=۱.۲۵ and (۱-x=۰.۰۶, ۰.۵٤, ۱)