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SYNTHESIS AND OPTICAL CHARACTERIZATION OF Co NANOPARTICLES DISPERSED ON POLYMER MATRIX BY GAMMA RADIATION

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ABSTRACT

Cobalt nanoparticles were synthesized using reduction of ^{60}Co gamma source with dose range 10-50 kGy in the presence of polyvinyl alcohol (PVA) polymer as a capping agent. Radiation synthesis has the advantages of without the use of reducing agent and catalyst and the cobalt nanoparticles aggregated immediately upon irradiation. The Ultraviolet-visible spectrophotometer and Nanophox measurement revealed the formation of cobalt nanoparticles by exhibiting surface plasmon absorption maxima at 500 nm. The size distribution of the cobalt nanoparticles was influenced by the concentration of $CoCl_2$ and absorbed dose of gamma rays irradiation .

Keywords: Co; nanoparticles;

INTRODUCTION

Metal nanoparticles embedded in matrices show properties significantly different from those observed in the bulk materials and are of great interest for numerous applications like optical and magnetic based devices. When the nanoparticles are embedded or encapsulated in a polymer, the polymer terminates the growth of the particles by controlling the nucleation. To protect the oxidation of these nanoparticles from the atmospheric oxygen and the synthesis is controlled by ascorbic acid. The gamma ray method is based on the interactions of gamma rays with matter to produce electrons, which in turns reduce the metal ions of metal salt into metal and started nucleation and aggregation. The number of electrons induces by radiation depends on radiation dose. Advantages to the use of the irradiation techniques include the metal nanoparticles produced are highly pure, fully reduced and highly stable state.

MATERIALS AND METHODS

Cobalt Chloride anhydrous, 99.0%, polyvinyl alcohol (PVA, average molecular weight Mw 8000, Acros Organics) and ascorbic acid were obtained from Sigma–Aldrich. Co nanoparticles were synthesized in an aqueous solution by chemical reaction method under gamma radiation. To prepare the solution, different concentration which is 1.0%,

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1.5%, 2.0%, 2.5% and 3.0% $CoCl_2$, 3g of PVA and ascorbic acid were added into 100 ml deionized water and continuously stirrer for 6 hours. The solution were separated into bottles before it was irradiated in a ^{60}Co gamma source with a dose rate of 3.66 kGy/h for total absorbed doses of 10 kGy, 20 kGy, 30 kGy, 40 kGy and 50 kGy. The optical characteristics were measured using Ultraviolet-visible spectrophotometer (SHIMADZU 1650 PC) in the wavelength range from 190 to 1100nm. The structure of cobalt nanoparticles nanoparticles in film was measured using XRD (7602EA Philips) and cobalt nanoparticle size in emulsion was measured using Nanophox (SYMPATC) from 1nm to 10000nm.

The optical absorption coefficient α(λ) was calculated from the absorbance A, using the following equation:

$$\alpha(\lambda) = 2.303(A/d) \qquad (1)$$

where *d* is the thickness of the samples.

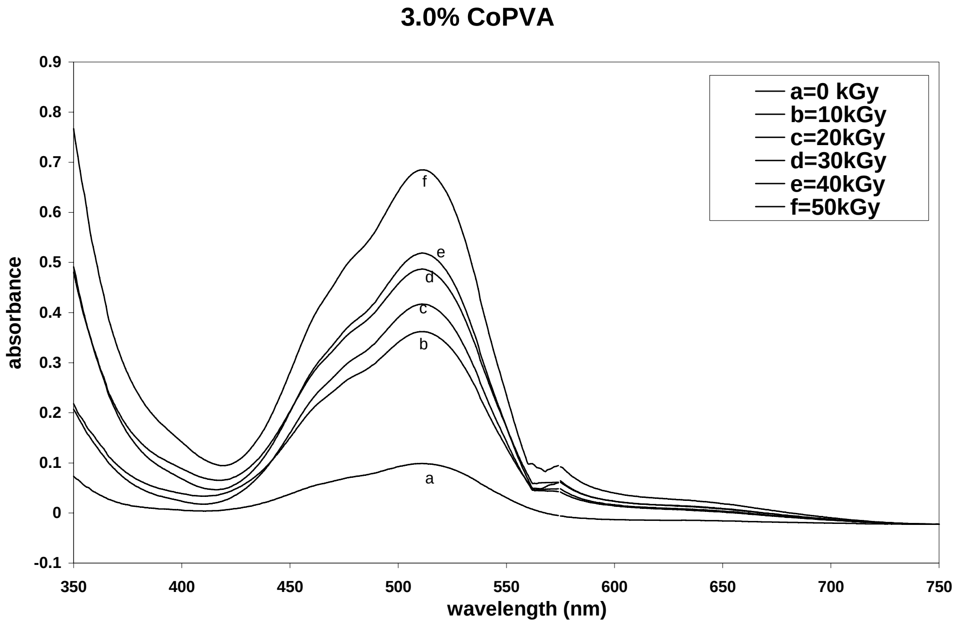

Figure 1: The absorption spectra of Co nanoparticles at different doses

The spectra in Figure 1 show a main absorption band in the UV region peaking at 500 nm due to cobalt nanoparticles. The absorption peak increases gradually with the increasing of dose. Figure 2 shows the size of Co nanoparticles at different concentration and different doses. At higher gamma ray dose, the size of the nanoparticles decreases due to more nucleation process and faster aggregation process in the formation of Co nanoparticles. The number of nanoparticles increases as the nucleation process increases at higher dose.

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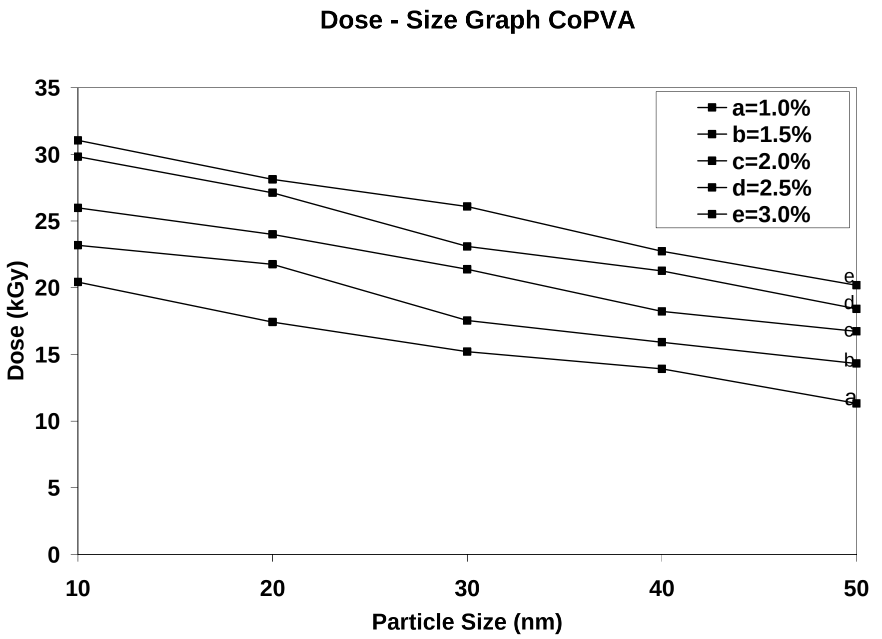

Figure 2: Average size of different concentration and different doses of Co nanoparticles

Table 1: Values of E_{opt} and ΔE (Urbach energy) calculated at 50kGy irradiated CoPVA

CoPVA (mol%)	Particle size (nm)	Absorption edge (±0.05 eV)	E_{opt} (eV) ± 0.01 Direct	ΔE(eV) ±0.01
1.0	11.32	4.92	2.61	1.18
1.5	14.32	4.84	2.53	0.60
2.0	16.72	4.75	2.46	0.34
2.5	18.42	4.72	2.37	0.28
3.0	20.18	4.71	2.28	0.24

The absorption edge is the minimum energy of light being absorbed by the material. The value of absorption edge energy decreases, competing with the increase of dose and concentration. The effect of gamma rays is very significant due to increasing the disorder as a concequence of the change of chemical structure in the polymer blend systems. Thus, larger influence of gamma rays in the optical properties is connected with higher degree of disorder caused in the amorphous material. More nanoparticles formed at higher doses. The effect of reflection size of nanoparticles is more prominent as the activation energy decreases from the 1.18eV at 1.0% CoPVA to about 0.24eV at 3.0% CoPVA. The is electron excitation at the conduction band of cobalt nanoparticles.

CONCLUSION

In this paper, we have presented the synthesis of Co nanoparticles in the range 26nm to 74nm. The size of nanopaticles were measured by Nanophox, XRD and TEM. Very good agreement we can see which is just a little agglomeration and size distribution of the prepared nanoparticles are small. It is evident that particle size and its distribution controlled both by controlling the rate of reaction dose and concentration of sample. The results clearly indicate that when the dose increases, the size of the nanoparticles increases. Co nanoparticles of nearly uniform monoclinic were synthesis by chemical reaction method in the presence of PVA as a polymer matrix.

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