Green synthesis of cobalt nanoparticles, its characterization and antimicrobial activities

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Abstract

In the present study, cobalt nanoparticles were synthesized by an recyclable and cost effective method using ocimum sanctum extract and characterized using various techniques such as UV-visible spectrophotometry, Fourier transform infrared spectrometry(FT-IR) and Scanning electron microscopy(SEM) coupled with Energy dispersive micro analysis(EDAX) and XRD. The spectroscopic methods confirmed the formation of cobalt nanoparticles and the microscopic technique confirmed the shape and size of the cobalt nanoparticles as spherical. Antibacterial activity of the synthesized nanoparticles was measured by zone inhibition method. The cobalt nanoparticles showed effective antibacterial activity against human pathogenic bacteria such as Pseudomonas Aeruginosa and Escherichia coli. The usage of plant extract for the preparation of Cobalt nanoparticle makes the process cost effective, non-hazardous and green method.

Keywords: cobalt nanoparticles, ocimum sanctum leaf extract.

INTRODUCTION

Nanoparticle research is presently an area of strong scientific interest due to a wide variety of potential application in biomedical, optical and electronic fields. Cobalt is considered to be the first catalyst made from nonprecious metal with properties closely matching with those of platinum[1]. The shape and size of the nanoparticles influence the physical characterization of these novel materials. Nanoparticles are the nano-sized particles[2-3] which have found various applications in the fields of medicine[4-7], biology [8-11], catalysis[12-14]etc. The nanoparticles can be synthesized by physical, chemical or biological methods. Cobalt nanoparticles can be synthesized by various approaches like ultrasonic spray pyrolysis, DC magnetron sputtering[15], thermal decomposition[16],electrochemical[17] and Liquid-Phase Reduction[18] process and also by biological methods such as microbial synthesis [19] of nanoparticles. Recently, many studies have proven that the plant extracts act as a potential originator for the synthesis of the nanomaterials in harmless ways. The plants are used successfully in the synthesis of several greener nanoparticles such as cobalt, copper, silver, gold, palladium, platinum, zinc oxide and magnetite. Plant mediated biological synthesis of nanoparticles is gaining importance due to its simplicity, cost effective and eco-friendliness [20-21]. Cobalt nanoparticles could be efficient nanoparticles as they possess good catalytic[22-23] and high performance permanent magnetic properties[24-25] and also possess biomedical[26] and cytotoxic[27] activity.

Here we have taken into account green chemistry concept and synthesized cobalt nanoparticles by using osmium santum leaves extract. Osmium sanctum (tulsi) is cultivated for spiritual and therapeutic purposes

and essential oil. It is widely known across South Asia as medicinal plant and herbal tea and commonly used in Ayurveda's.

EXPERIMENTAL

Experimental set up is very simple it consists of magnetic stirrer. The 100 ml round bottom flask is fitted with metallic stand. Flask is kept on magneric stirrer for constant stirring.

MATERIAL AND METHOD

Experimental Details:

Preparation of 50 mg/ml cobalt solution

For the preparation of cobalt solution we use the cobalt chloride 50.46 gm of $CoCl_2$ dissolved in double distilled water and dilute to 250ml of water.

Preparation of leaf extract (Ocimum sanctum)

Exactly 30 gm of ocimum sanctum leaves were taken in clean beaker then washed thoroughly with doubled distilled water. The leaves were dried on filter paper to remove the excess water then add 100 ml distilled water by using volumetric flask and boiled to get leaf extract and stored in umber colour bottle and keep in refrigerator.

Synthesis of cobalt nano particles:

Add 20 ml 50 mg/ml cobalt solution in a round bottom flask then add 1-2 ml of osmium sanctum leaf extract with constant stirring again add 60 ml of leaf extract the dark bluish colour was observed which indicates the formation of cobalt nanoparticles Fig.1. Then synthesized cobalt nanoparticles were characterized by UV visible spectroscopy. Then keep the flask for 24 hrs for setting the particles. After 24 hrs the resulting solution is centrifuged for 20 mins at 500 rpm, then centrifuge and discard the aqueous layer and remove the residue with little amount of distilled water then keep it for dehydration in plane surface glass dish with covering. After 2-3 days dehydration is completed then collects the particles which are present on surface of glass.

Characterization of cobalt nanoparticles:

Dark bluish colored indicates cobalt nanoparticles are synthesized and detected by using UV-Visible spectroscopy, Morphology of cobalt nanoparticles using Scanning electron microscopy (SEM), X-ray diffraction spectroscopy (XRD) and Elemental analysis was performed by Electron Diffraction X-ray analysis (EDX).

Fig.1 A: Cobalt solution; B: plant Extract; C: Cobalt Nanoparticles

RESULT AND DISCUSSION

UV visible spectroscopic analysis of cobalt nanoparticles:

The UV visible spectroscopy is most widely used technique to investigation the optical properties of the particles. The colours changes from Pink to dark bluish colour which indicates formation of cobalt nano particles.UV visible spectroscopy analysis was done in the range of 200-800 nm and maximum absorbance was observed at 646 nm region for the formation of cobalt nano particles Fig. 2

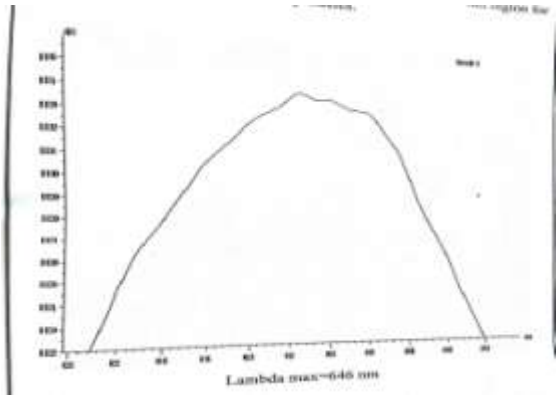

Fig. 2. UV-Visible spectrum of Co-NPs

FTIR of cobalt nanoparticles

FTIR measurements were carried out to identify the possible biomolecules responsible for the reduction of cobalt and capping of cobalt nanoparticles. The FTIR spectrum of cobalt nanoparticles represents the major absorption bands as the bands 1100-1150 cm^{-1} represents C-O stretching. The bands 1640-1650 cm^{-1} indicates C=C stretching. The bands 1050-1080cm^{-1} assigned phenolic or alcoholic group. Fig. 3.

Bands on these results the presence of phenolic compound and protein were believed to be responsible for the formation and stabilization of synthesized cobalt nanoparticles.

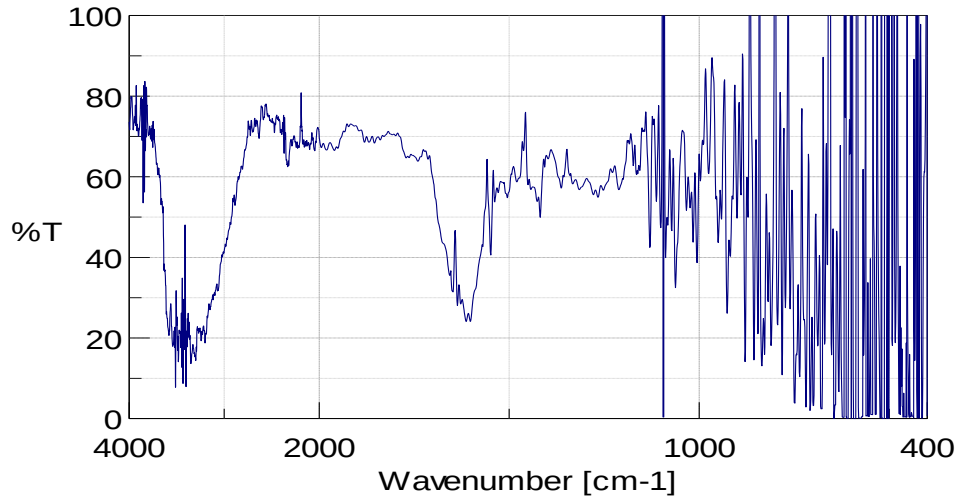

Fig. 3 FTIR Spectrum of Co-NPs

XRD Analysis of cobalt nanoparticles:

Analysis through X-ray diffraction was carried out to confirm the crystalline nature off cobalt nano particles Fig. 4. The dry powders of cobalt nanoparticles were used for XRD analysis. The diffracted intensities were recorded from 20^0C to 100^0C.At 2Ɵ angles. The comparison of our XRD spectrum with the standard confirmed that cobalt nanoparticles form were in the form of nano crystals as different diffraction lines were observed at 2Ɵ angle 15,16,20.5,22.5 respectively. The average particles size of the cobalt nanoparticles synthesized by present bio synthesis method can be calculated by using Debye-Scherer's equation.

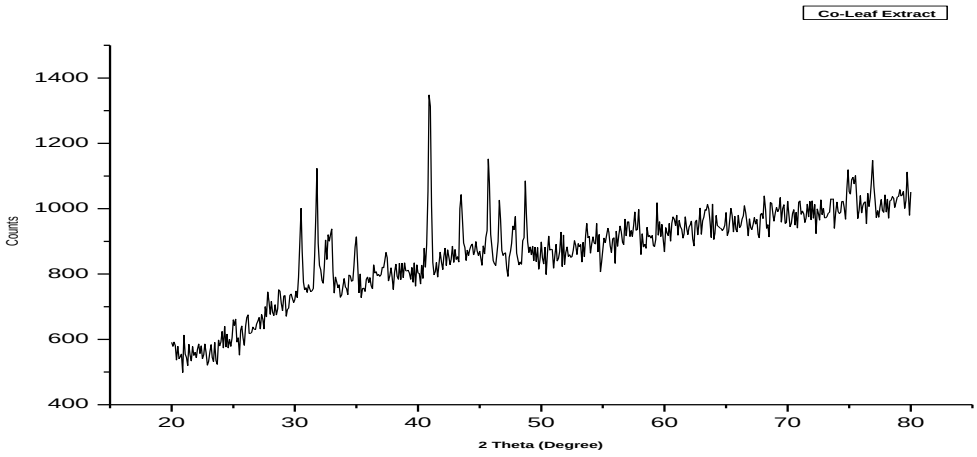

Fig. 4 XRD Spectrum of Co-NPs

Scanning electron microscopy

Analysis of the sample performed using SEM method. Scanning electron microscopy provided the morphology and size details of the cobalt nanoparticles. It was identified that shapes of cobalt nano particles appeared like irregular spherical shape with rough surface Fig. 5.

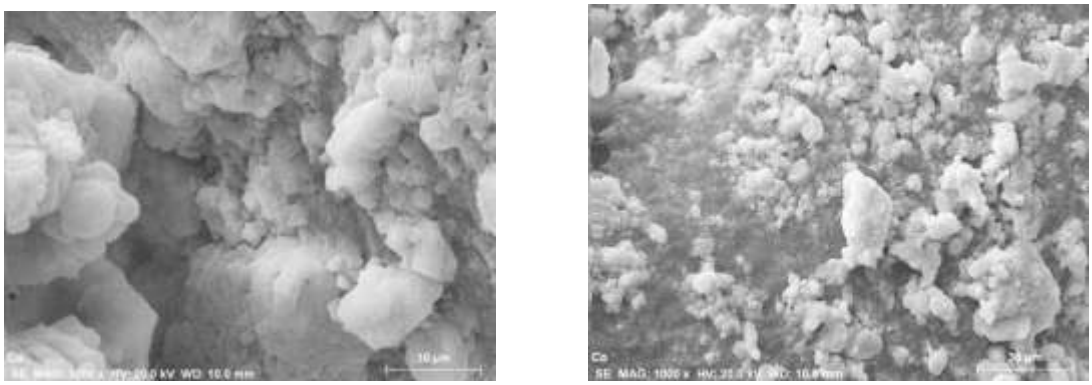

Fig. 5 SEM Image

Energy dispersive micro analysis (EDAX)

The element analysis of cobalt nano particles was studied using energy dispersive micro analysis (Edax). The analysis revealed highest proportion of cobalt in the nano particles followed by carbon, oxygen and chloride. Fig. 6.

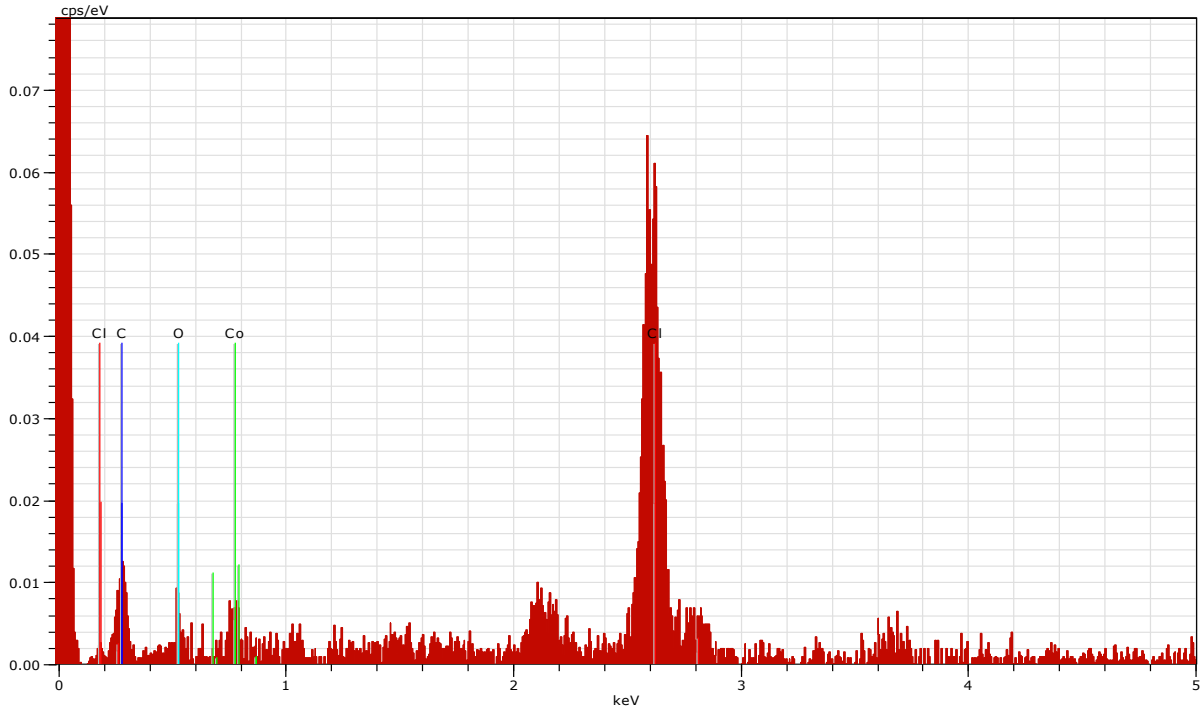

Fig. 6 Energy dispersive micro analysis (EDAX)

Spectrum: Co

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error [%]
Co	27	K-series	15.18	28.03	9.86	0.9
O	8	K-series	14.51	26.80	34.73	8.3
C	6	K-series	13.75	25.40	43.85	8.4
Cl	17	K-series	10.70	19.77	11.56	0.6
		Total:	54.14	100.00	100.00	

Antimicrobial Activity of Cobalt Nano particles

Antibacterial activity of cobalt nano particles were checked against two bacterial pathogens such as Pseudomonas Aeruginosa Fig. 7 and Escherichia coli Fig. 8, Cobalt complex was shown better result in the form of zone of inhibition in culture plates for these organism were found to be 2.1 mm and 1.6 mm respectively.

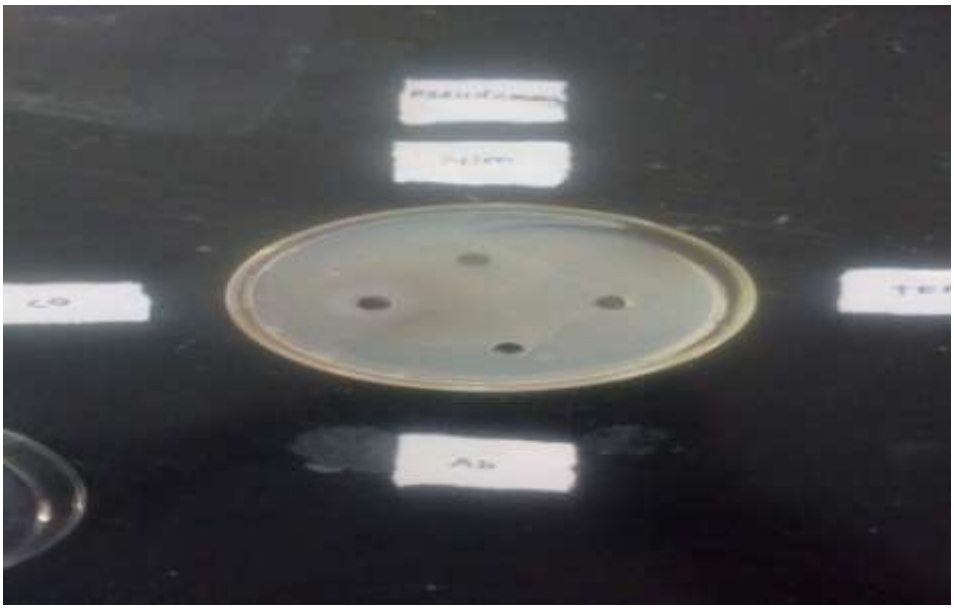

Fig. 7 Pseudomonas Aeruginosa

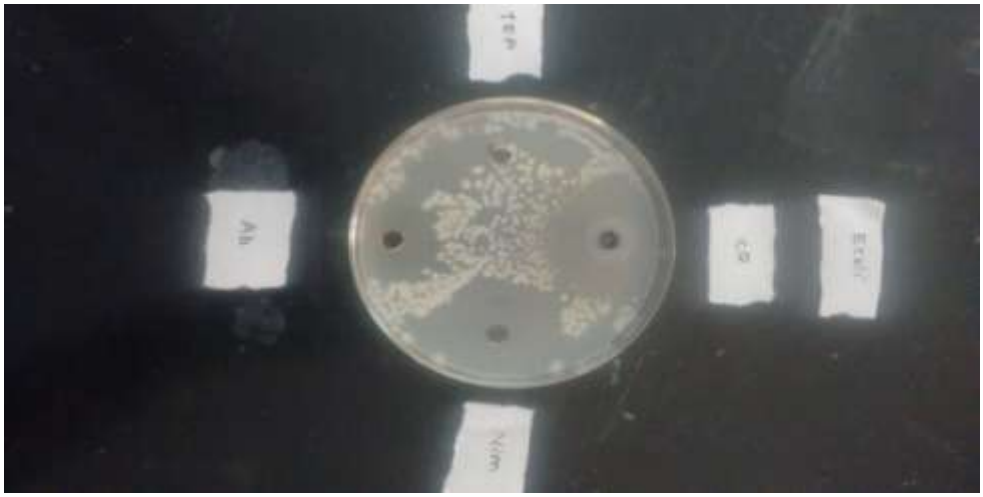

Fig. 8 Escherichia coli

CONCLUSION

In this study simple approach was attempted to obtain a green eco-friendly, non-toxic way for synthesis of cobalt nanoparticle. The primary confirmation for cobalt nanoparticle was due to colour changes and UV/Vis absorption spectra of cobalt nanoparticles formed peak at 646 nm.The SEM study was identified that the shape of cobalt nanoparticle appeared like irregular spherical shape with rough surface. Edax study was to find out percentage of cobalt, oxygen, carbon and Chlorine antimicrobial activity of cobalt nanoparticle shows better zone of inhibition against two bacterial pathogen i.e. Pseudomonas and E.coli.Green synthesis method is rapid, convenient and less time consuming environmentally safe method for the synthesis of cobalt nanoparticles.

Acknowledgement

Authors are thankful to the Management PRESS, Loni for providing necessary facilities in department.

REFERENCE

[1] Y. Yu, A. Mendoza-Garcia, B. Ning, and S. Sun, "Cobalt substituted magnetite nanoparticles and their assembly into ferrimagnetic nanoparticle arrays," *Advanced Materials*, vol. 25, no. 22, pp. 3090–3094, 2013.

[2] L. J. Jongh. Physics and Chemistry of Metal Clusters Compounds, Kluwer Academic Publishers, Dordrecht.doi:10.1007/978-94-015-1294-7, 1994.

[3] G. B. Budkevich, I. B. Slinyakova and I. E. Neimark. Colloid Journal, 28 (1):pp. 21-25, 1996.

[4] Kreuter. J, Gelperina. S.Tumori, 94: pp.271–277, (2008).

[5] Yoon K. Y. Hoon B. J. Park J. H. Hwang J. Sci. Total Environ,

a. 373:pp.572–575, 2007.

[6] W. B. Tan, S.Jiang, Y.Zhang , Biomaterials, 28: pp.1565–1571, 2007.

[7] Su J, Zhang J, Liu L, Huang Y, R.P.Mason, Journal of Nanosci. Nanotechnol, 8: pp.1174–1177, 2008.

[8] L.R. Hirsch , R.J. Stafford , J.A. Barkson , S.R.Sershen ,B.Rivera , R.E.Price, J.D.Hazle,N.J.
[9] Halas,West JL. PNAS, 100: pp.13549-13554, 2003 .
[10] Y.Matsumura, K.Yoshikata, S.Kunisaki, T.Tsuchido. Appl. Environ. Microbio. 69: pp.4278-4281,2003.
[11] A.Ingle, A.Gade, S.Pierrat, C.Sönnichsen, M.Rai, CurrNanosci, 4:pp.141-4, 2008.
[12] S.Pal, Y.K. Tak, J.M.Song. Appl EnvironMicrobiol, 73:1712-20,2007.
[13] A.Nadiia, Ivashchenko, WojciechGac, A.Valentyn,Tertykh, V.Viktor,Yanishpolskii, A.Sergei,
a. Khainakov, V. Alla, Dikhtiarenko, Sylwia Pasieczna-Patkowska, Witold Zawadzki.
b. World Journal of Nano Science and Engineering, 2: pp.117-125,2012.
[14] M.Muneer, Ba-Abbad, Abdul Amir H. Kadhum, Abu Bakar Mohamad, S.Mohd, Takriff,
a. Kamaruzzaman Sopian. Synthesis and Catalytic Activity of TiO2 Nanoparticles for Photochemical Oxidation of Concentrated Chlorophenols under Direct Solar Radiation, 7: pp.4871-4888,2012.
[15] Chao Lin, Kai Tao, DayinHua, Zhen Ma and Shenghu Zhou.Molecules, 10(18): pp.12609-12620, 2013.
[16] Bing-Xian Chung, Chuan-PuLiu . Materials Letters, 58: 1437–1440.
[17] E.Sowka, M.Leonowicz, B.Andrzejewski A. D. Pomogailo G. I. Dzhardimalieva, Materials Science poland, 24(2),2006.
[18] Ledo-Suárez,L.Rodríguez-Sánchez,M.C.Blanco,M.A.López-Quintela,phys.stat. sol,203(6):pp.1234 – 1240,2006.
[19] Mary donna BellelBalela , Liquid-phase reduction and synthesis and characterization of cobalt nanoparticles prepared by liquid-phase reduction, University Sains Malaysia, 2008.
[20] K.Rashmi, T.Krishnaveni, S.Ramanamurthy and P.Maruthi Mohan, Characterization of cobalt nanoparticle from a cobalt resistant strain of neuro sporacrassa, International Symposium of Research Students on Materials Science and Engineering December, Chennai, India, Department of Metallurgical and Materials Engineering, Indian Institute of Technology, Madras,2004.
[21] R.Yogeswari, B.Sikha, Akshya Kumar, P.L. Nayak, Journal of Microbiology and Antimicrobials, 4(6):pp.103-109,2012.
[22] M.A.Farooqui, P.S.Chauhan, P.Krishnamoorthy,J.Shai, Journal of Nanomaterials and Biostructures, 5:pp.43-49,2010.
[23] DUAN Hongzhen, LIN Xiang yang, LIU Guanpeng, XU Lei and LI Fengsheng, journal of Chem. Sci,118(2):pp.179–184,2006.
[24] R Venkat Narayan, Vinodkanniah and Aruna Dhathathreyan, ChemSci Trans, 2(1):pp.47-50, 2013.
[25] Saeed Farhadi ,Jalil Safabakhsh and Parisa Zaringhadam ,Journal of Nanostructure in
a. Chemistry3(69),2013.
[26] H. T. Yang, Y. K. Su,1, C. M. Shen, T. Z. Yang and H. J. Gao ,Surface and Interface
a. Analysis Surf. Interface Anal 36:pp.155–160,2004.

[27] C. Osorio-Cantillo A. N, Santiago-Miranda O, Perales-Perez and Y. Xin, Journal of Applied Physics 111,2012.

[28] Elena Papi, Federica Rossi, Mario Raspanti, Isabella Dalle-Donne, Graziano Colomb, Aldo Milzani, Giovanni Bernardini, Rosalba Gornati,Toxicology Letters, 189:pp.253–259,2009.