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Eco-friendly synthesis and characterization of strontium oxide nanoparticles by reduction method

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Abstract
Strontium Oxide Nanoparticles was synthesized by using piper betle leaf extract. This method is used as cost effective and eco-friendly green method assisted by piper betle leaf extract. The UV absorption spectrophotometer analysis of leaf extract and metal compounds showed absorbance spectra range is in 200-800 nm. The UV-Vis spectroscopy shows surface Plasmon resonance of SrO nanoparticles at 240 nm. The adsorption peak up for different size of nanoparticles is due to a physical process of surface Plasmon resonance indicates the particles are poly dispersed. The FT-IR measurements were carried out to identify the formation of Strontium oxide nanoparticles and possible molecules such as OH, C=C, C=O and aromatic compounds. The FT-IR analysis played a pivoted role in displaying the nanoparticles which showed strong absorbance in the range 900-700 cm^{-1} for Strontium oxide nanoparticles. The diffraction peaks and planes of ions are indexed. From the 'X' ray diffraction analysis, the size of the Strontium oxide nanoparticles is 42 nm calculated by Debye scherrer's equation. The size, shape and structure of nanoparticles were also analyzed by scanning electron microscope and it shows almost spherical shape of nanoparticles aggregation. This green synthesis method has many advantages over the chemical method, because it reduces the use of toxic metals in the synthesis process.

Keywords: Piper beetle leafs, green synthesis, strontium oxide nanoparticles, characterization, applications

Introduction
The field of nano technology is one of the most active researches in modern material science. Nanotechnology is emerging as a rapid growing field with its application in science and technology for the purpose of nano facing new scale materials at the nano scale level. Nano size materials exhibit unique electronic, magnetic, optical, catalytic and medicinal properties as compared with the traditional and commercial bulk materials [1]. It is due to the quantum size effect and large surface to volume.

Bio synthesis of nanoparticles is a kind of bottom up approach where the nano reaction occurring as reduction and oxidation. The plant phytochemical's with anti-oxidant and reducing properties are usually responsible for reduction of metal compounds into their respective Nanoparticles. The Bio organism is a eco-friendly reducing agent and also employed as a capping agent. Strontium oxide nanoparticles also referred to as Strontium monoxide or strontia. Strontium produce strontium oxide when exposed to air which replicates the properties of strontium. Strontium oxide or Strontia is basic in nature and is in the form of white powder. The synthesis of nanoparticles from oxides of transition metals such as strontium oxide (SrO) is significant due to the structural diversity and wide range of applications. For a long time, SrO Nanoparticles have been investigated for their promising applications in manufacture of gas sensors, lithium-ion batteries, solar cells, doped dye-sensitive solar cells, transistors, catalyst supports, super capacitors and electrodes for semiconductors [2-6]. SrO Nanoparticles were aimed to be synthesized and characterized is more efficient, economical and moderate conditions using piber betle leaf extract. Piper betle leaves are extensively grown in India and are widely used as a post meal mouth freshener. Due to strong pungent aromatic flavor, betle leaves are used as masticators by the Asian people [7-8]. Piper betle L. is an aromatic, shade-preferring climber cultivated mainly in India and other tropical Asian countries. The betle leaf is familiar as Paan in India. Research on Piper betle showed a vast number of pharmacological benefits, such as antioxidant, antimicrobial and anti-inflammatory properties. There are few studies are reported related to this research work such as Green synthesis of Fe_2O_3 nanoparticles using piper betle leaf and its characterization [14] and Piper betle – mediated synthesis, characterization, antibacterial and rat splenocyte cytotoxic effects of copper oxide nanoparticles [10]. Green synthesis method is one of the most convenient technique to synthesis the Strontium oxide nanoparticles, because of the cost effectiveness environmental friendliness easily scaled for large scale synthesis. The aim of this work is to synthesis the Strontium oxide nanoparticles in a green bio genetic way of Bio Reduction method. It will find important and specific uses. A detailed structural characterization of the newly synthesized sample have been carried out.

Materials and Methods

Materials

For the synthesis of Strontium oxide nanoparticles, the piper betle leaf extract is used as a reducing agent. The Strontium nitrate solution is used as a precursor for preparing the Strontium oxide nanoparticles.

Preparation of Piper beetle leaf extract

The fresh leaves of piper betle were collected from a local area. 10 g of fresh leaves were washed thoroughly under the running tap water and finely cut into leaves. 50 ml distilled water is added to it in a 250 ml beaker. Then boiled for 10 min before decanting it. The extract was used for further experiments.

Green synthesis of Strontium oxide nanoparticles

0.5 M Strontium nitrate solution was prepared with 30 ml of water. Then 20 ml piper betle leaf extract was added to above solution and stirring for 10 min. After wards 0.5 ml H_2SO_4 (5M) was added into the above dispersion. The suspension was transferred to 50 ml Teflon - lined stainless steel autoclave. The autoclave was heated to the 200 °C and maintained for 3h in an oven and naturally cooled down to the room temperature. The sediments were centrifuged, washed with water, calcined at 300 °C for 2h to get Strontium oxide nanoparticles [11].

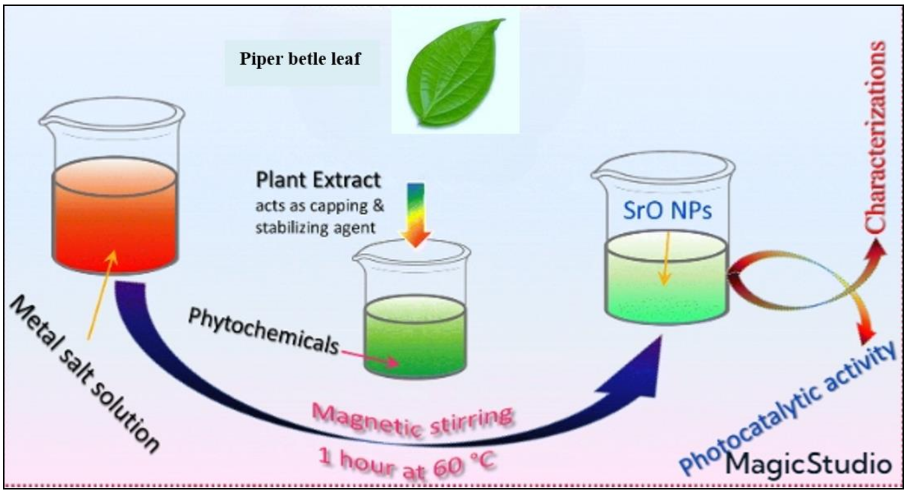

Fig 1: Schematic diagram

Characterization

The structural properties of the green synthesized Strontium oxide nanoparticles was characterized by XRD pattern using BRUKKER binery V3 (Raw) Model. The surface morphology and elemental analysis of the synthesized sample was examined by a scanning electron microscope using MAKE-Ziess model - EVO18. The optical absorption spectrum of the synthesized sample was evaluated by UV-visible spectrophotometer with wave length rays of 200-400 nm. FTIR spectrum of synthesized sample was recorded over the range of 400 – 4000 cm^{-1} in a FTIR perkinelmer model.

Results and Discussion

The Bio reduction form of Strontium oxide nanoparticles was obtained and monitored by measuring UV – Vis spectrum using spectrophotometer. The UV-Vis absorption peak for different size nano particles is due to physical process of surface Plasmon resonance. UV – Vis spectrum is recorded from the reaction. The absorbance peak was observed at 240 nm. The UV spectrum could be used to examine the size and shape controlled Strontium oxide nanoparticles. The figure (1) below shows that the UV spectrum recorded from the reaction media. The band gap of the material is assessed which depends upon the localization of orbitals the band energy of SrO nanoparticles is found to be 2.64 eV which is higher then energy band gap of Bulk SrO nanoparticles (1.8 eV). According to quantum confinement effect, a decrease in particles size is directly proposed to an increase in energy band gap.

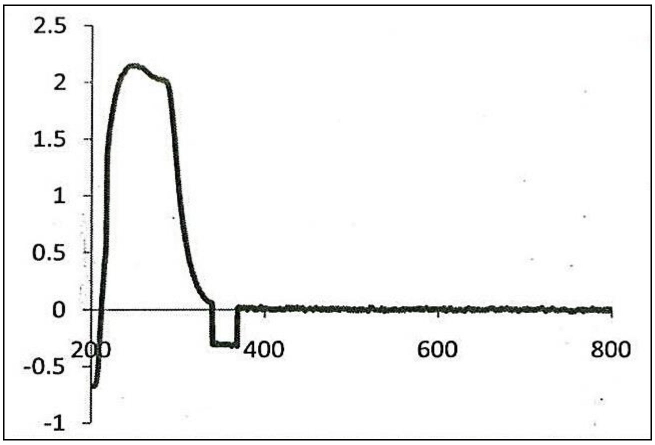

Fig 2: UV – visible spectrum for SrO nanoparticles

FTIR spectra for the Strontium Oxide nano particles are shown in the figure 3. The strong broad absorption peak at about 1377 is attributed to the asymmetric stretching vibration of Sr-O. The stretching vibration of Sr-O Sharp absorption bands at 832 cm^{-1}. 734cm^{-1} can be attributed to out of plane bending vibration of Sr-O [12]. The Peak 732 in FTIR which is due to Sr-O bond. Hence, the SrO nanoparticles which shows the sample had strong absorbance in the 641-734 cm^{-1}, the other absorption peak were observed due to the presence of other organic molecules such OH, CH, C-O, C-C, C=O, C-N, C=C and Alkene.

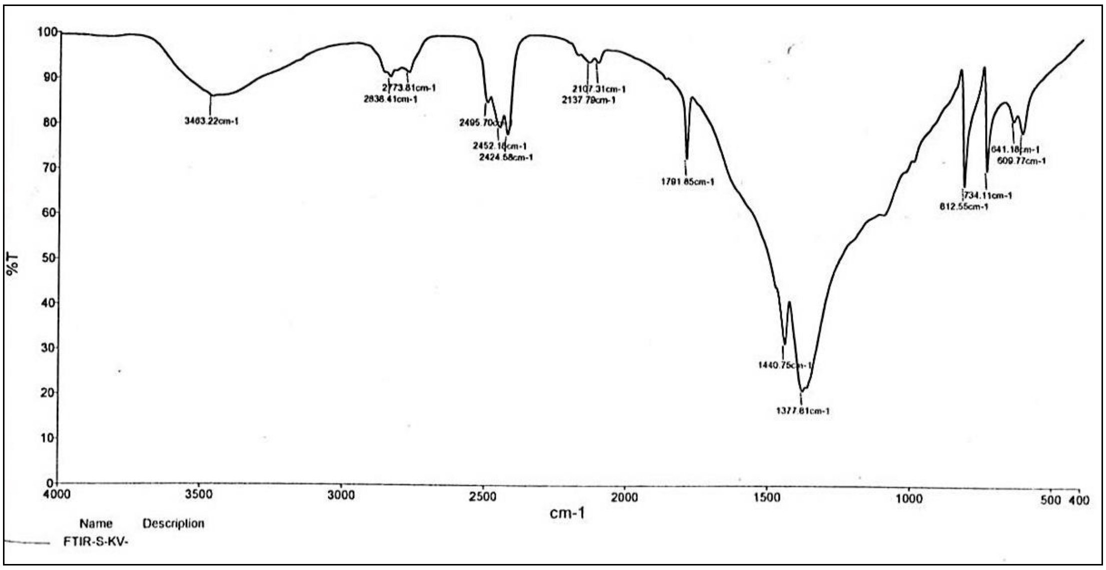

Fig 3: FT-IR spectra for formation SrO nano particles

In the present work, the prepared SrO nanoparticles are characterized by XRD particles size was determined from the width of XRD peaks using Scherrer's formula [13],

$$d = \frac{(0.94\ \lambda)}{(\beta\ Cos\ \theta)}$$

Where, β is the full width half maximum, θ is diffraction angle, d is the average crystalline grain size and λ is wavelength of the 'X' rays. The phase identification and crystalline structures of the nanoparticles was characterized by X-ray powder diffraction sharpness of XRD peaks indicates the particles are having in crystalline nature. The Sharp intense diffraction in the pattern match well with SrO nanoparticles having lattice constant 3.6A^0 (B_1 Phase) and 3.14A^0 (B_2 Phase).

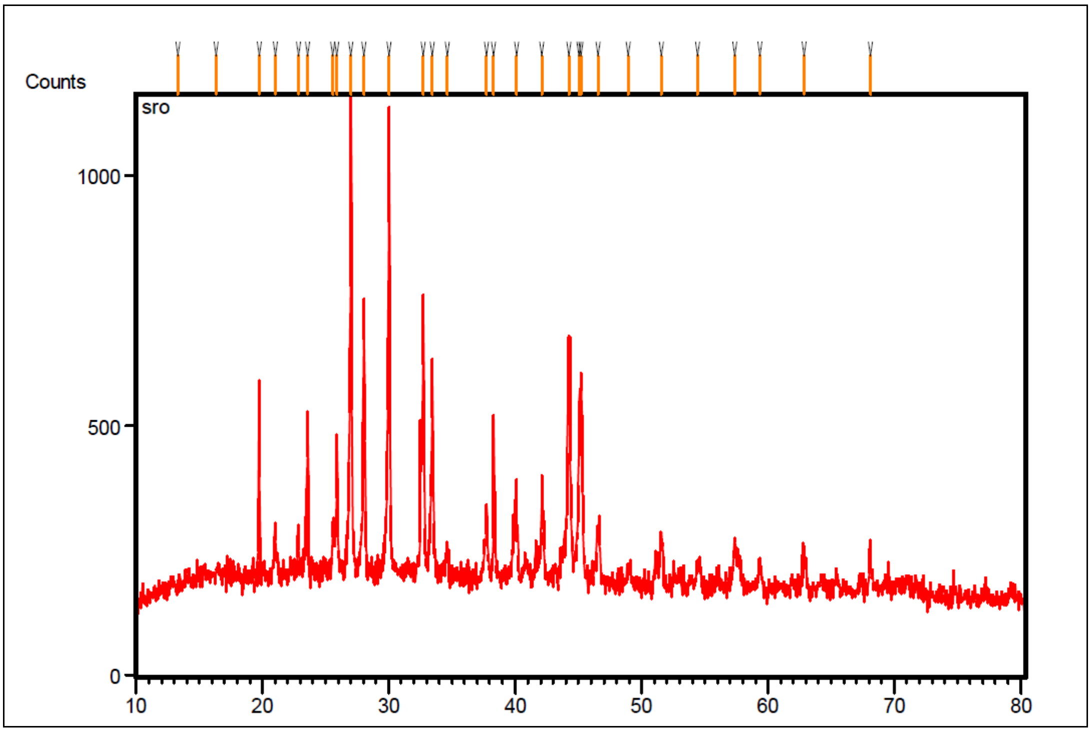

Fig 4: The common crystals habit of SrO

Diffraction sample of SrO nanoparticles and shown in fig 4. The common crystals habit of SrO is spherical in shape. The width of the peaks of SrO nanoparticles has increase due to quantum size effect. The average particles size was calculated by scherrer's equation is 42 nm. The peak observed the specimen at 2 θ valves of 18.156^0, 20.073^0, 23.225^0 are shown in Table and corresponding to (011) (112) (202) (111) (113) planes of Strontium respectively. The unassigned peak could be due to the pressure of crystallization of bio organic phase that occurs on the surface of the nanoparticles.

SEM image of the SrO, nanoparticles obtained from the SEM analysis. It was observed that the SrO nanoparticles consisted of small spheres with a diameter of 20-50 $\pm$ 2.5nm and arranged as channels. The size, shape location and distribution of green synthesis SrO nanoparticles were characterized by SEM. The SrO nanoparticles SEM image showed in figure (5) indicates well dispersed particles that more or less spherical. The size of the nanoparticles is about 42 nm and also individual nanoparticles were aggregated shows large nanoparticles. This aggregation took place due to the presence of cell components on the surface of nanoparticles and acts as capping agent.

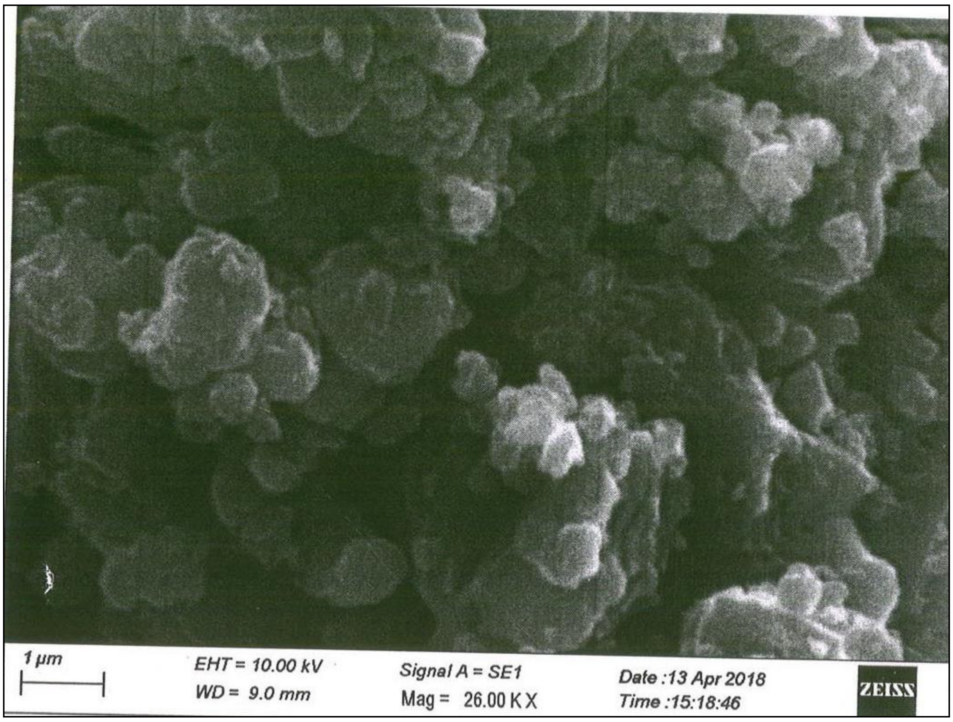

Fig 5: SEM image of the SrO

TEM

From the TEM image (Fig. 6), it has been observed that the particles appear to be of spherical shape and are distributed non-uniformly.

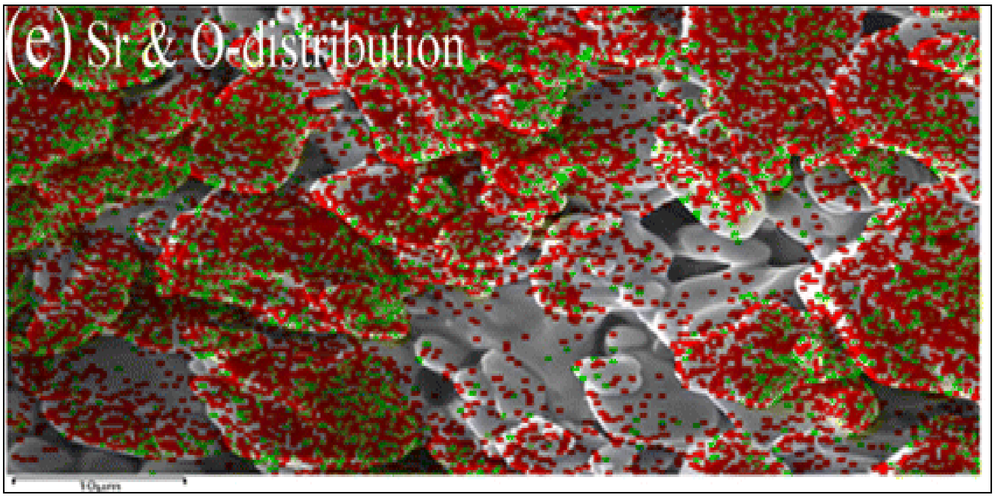

Fig 6: X-ray spectroscopy as shown

EDX

The elemental composition of SrO nanoparticles are determined by using energy dispersive X-ray spectroscopy as shown in Fig. 8. The EDX analysis indicates presence of Sr- and O elements, respectively and No other impurities are detected. The SrO atomic ratio in the SrO nanoparticles obtained from EDX analysis was 1: 1 in agreement with metal oxide formula. The EDX analysis confirms that the SrO particles consist only of metal and oxygen components which indicates the purity of the synthesized sample.

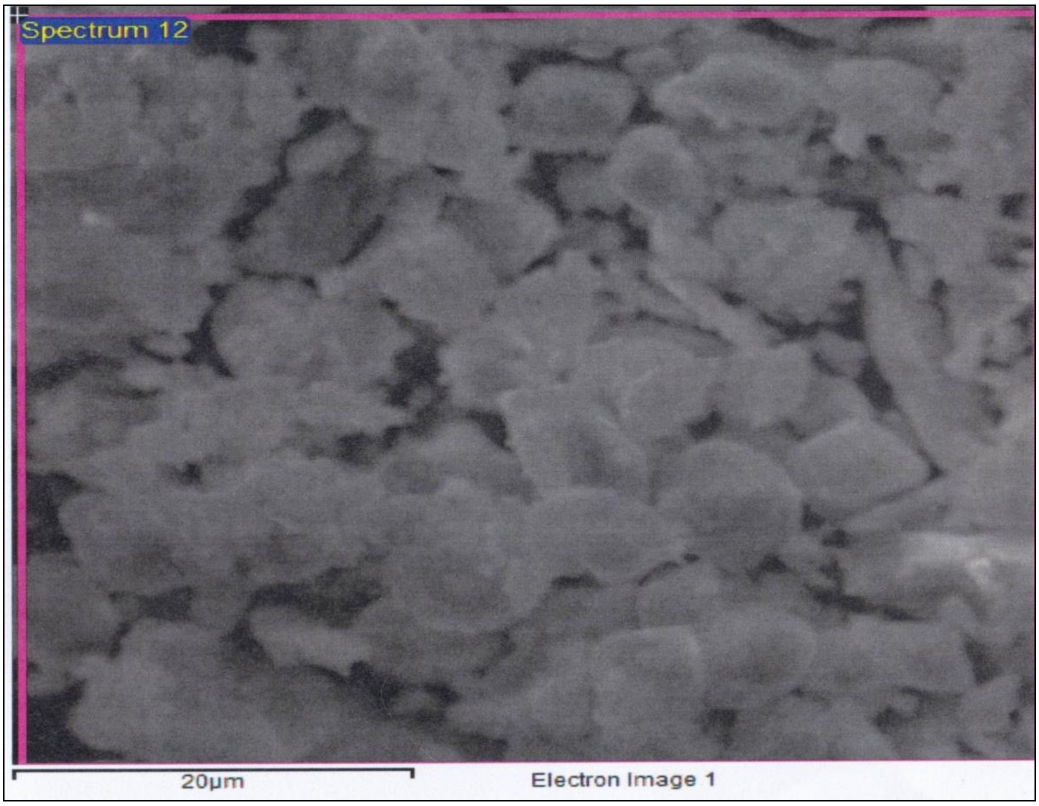

Fig 7: Spectrum 12

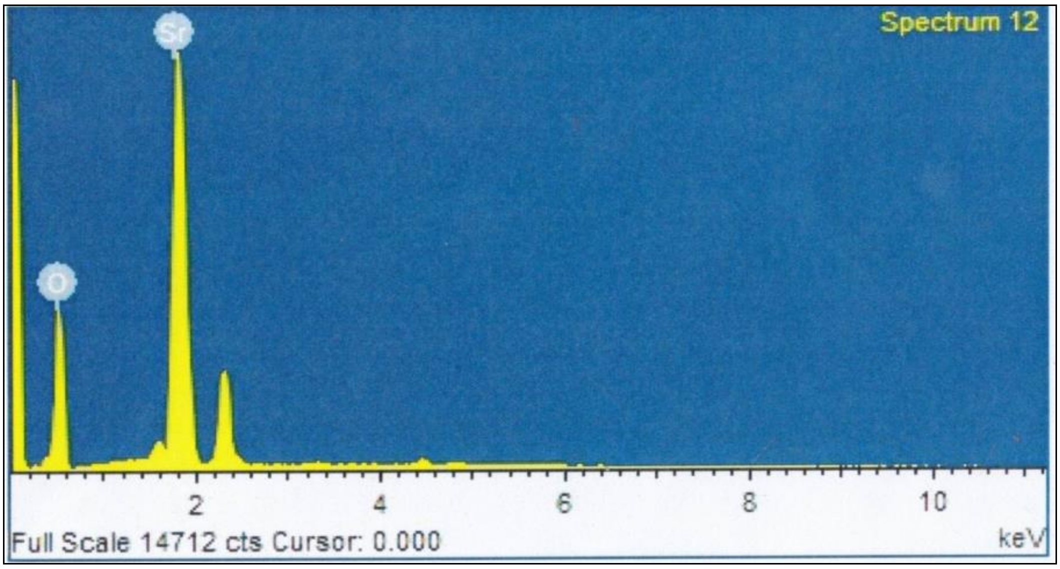

Fig 8: The EDX analysis indicates presence of Sr- and O elements

Conclusion

Strontium oxide nanoparticles were successfully synthesized by using piper beetle leaf extract as bio reduction method which provides simple and environment benign, more compatible, large scaled up process and less time consuming process. Leaf extract was acts a capping agent and reducing agent in nanoparticles synthesis. The UV absorption spectrophotometric analysis of piper beetle leaf and formed SrO nanoparticles showed that band was 203 nm which was identified the surface Plasmon resonance band and this band is described to excitation of valence electrons. FTIR analysis revealed the efficient and stabilization properties of these SrO nano particles. The FTIR spectrum showed that sharp absorbance for SrO is 832 $cm^{-1.}$ From the XRD study, the size of the nano particles is 42 nm calculated by Debye Scherrer's equation. The shape of nano particles was analysed by scanning electron microscope shows poly dispersed and spherical shape for SrO nano particles. Green synthesis method of nano particles is evolution from nano technology. Hence, Synthesis of metal Nanoparticles, characterizations and their applications to different fields have become an important trend in modern investigation and also SrO nanoparticles having a widespread use is an important and interesting research topic.

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