Electrical conductivity and ion exchange studies of nano sized cerium (IV) tungsto iodate — A new cation exchanger

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Nano particles of cerium tungsto iodate, a tetravalent metal acid salt, have been prepared by chemical co-precipitation method. The particle size of the sample has been calculated from its X-ray diffraction pattern and the average grain size is found to be 25 nm. The size is further characterized by SEM, TEM and FTIR analyses. Its dielectric behaviour at various temperatures (50°-110°C) and frequencies is also investigated. The dielectric constant values increase with the decrease in frequency and the increase in temperature. Moreover, the sample in its protonated form is subjected to ion exchange capacity studies. The data reveals that the sample works as a good ion exchanger.

Keywords: Cerium tungsto iodate, Cationic exchanger, Electrical conductivity, Ion exchanger

Nowadays, much interest has been developed in the study of ion exchange materials of the class tetravalent metal acid salts because of their selectivity and intercalation properties¹-⁴. Ion exchangers have wide range of applications in water processing such as desalination and in the chemical industries. Heteropolyacid salts based on tin(IV), titanium(IV), zirconium(IV) and cerium(IV) have been reported in the literature as ion exchange materials⁵. Properties of these materials are comparatively better than their simple metal salts. Moreover, these materials possess high dielectric values. The high dielectric materials are very important on account of their potential applications such as capacitors, memory devices, sensors, etc⁶-⁸.

The present study is concerned with the synthesis of nanoparticles of cerium tungsto iodate and its characterizations. The ac electrical conductivity behaviour of the samples at different temperatures and frequencies is explored. The ion exchange capacity as the cation exchanger is also explored with its protonated sample.

**Experimental Procedure**

Nano particles of cerium tungsto iodate (CTI) were prepared by arrested precipitation from equimolar solutions of analytical grade ammonium ceric sulphate, sodium tungstate, potassium iodate for which ethylene diamine tetra acetic acid was used as the capping agent⁹. A definite volume of each solution of the salts was added into the EDTA solution kept under a constant stirring with a magnetic stirrer. The precipitate of CTI thus formed was separated and washed several times with distilled water followed by ethanol to get pure sample. It was then dried and grounded to fine powder. The samples obtained were sized by sieving to 30-60 mesh size and converted to the hydrogen form completely by repeated treatment with 1M HCl, washed with demineralized water till free from chloride ions and then dried at 45°C. XRD, SEM, TEM and dielectric studies were done on the unprotonated samples.

The XRD analysis of the sample was done with XPERT-PRO powder diffractometer for which Cu- K-Alpha radiation was employed. The SEM image was taken from a scanning electron microscope (JEOL/EO JSM-6390). The TEM image was obtained from a Hitachi model H-800 transmission electron microscope, using an accelerated voltage of 200KV.

The dielectric and ac electrical conductivity studies for different temperatures and frequencies were carried out using a heating set-up (Matri Pondicherry, India) attached with the LCR meter.

The ion exchange capacity of the protonated sample was estimated by the column process. One gram of the exchanger (H⁺ form) was packed in a glass column and washed with demineralized water to remove any excess of acid that remained on the particles. 250 mL of 1M solution of different salts was passed through the column maintaining the flow rate at 1 mL/min. The effluent was collected and titrated against a standard NaOH solution to estimate the total H⁺ ions released.

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Results and Discussion

SEM image (Fig. 1) reveals that the particles are agglomerated to some extent and are more or less spherical in shape. The particle size obtained from the Scherrer equation and TEM (Fig. 2) image are found to be in the nanometer range.

Two plots, namely (i) dielectric constant versus frequency and (ii) ac electrical conductivity versus frequency at various temperatures (50°C-110°C) are depicted in Figs 3 and 4 respectively. It is observed that the dielectric constant decreases with the increase in frequency of applied field and reaches a steady value at high frequency range. The high values of the dielectric constant at low frequencies may be mainly due to certain polarization effects like space charge and rotation direction polarization. However, the dielectric constant increases with increasing temperatures for fixed frequencies. Orientation of more and more dipoles with the rise in temperature may be the reason.

The ac electrical conductivity is found to be high at high frequency ranges. It may arise from a small polaron hopping in the higher frequency regime. The results obtained from the study of ion exchange capacities of the protonated sample are present in Table 1. Variations in the ion exchange capacities of cerium tungsto iodate for Li⁺, Mg²⁺, Sr²⁺, Ca²⁺ and Ba²⁺ ions at room temperature are indicated in the Table 1. The ion exchange capacity is found to be minimum for Li⁺ ions and maximum for Ca²⁺ ions. Variations in the ion exchange capacities of Na⁺ ions are thoroughly studied for the samples at room temperature, 175°C, 350°C and 525°C. The data reveal that CTI in the nano protonated form behaves as a good ion exchanger.
**Conclusion**

Cerium tungsto iodate in the nano nature exhibits enhanced dielectric properties. The average particle size of the sample is estimated in the nano scale. The value of dielectric constant is found to be high at low frequency region. The ac electrical conductivity is found to be high at high frequency region. These properties are enhanced with the increase in temperature. The hydrogen form of the sample is found to be a powerful ion exchanger and hence a promising candidate as a good cation exchanger.

**References**