Characterization of different electrode materials and Resistive Plate Chamber detector performance studies

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Introduction

The India-based Neutrino Observatory (INO) [1] is a proposed underground laboratory in southern India. INO will house a large magnetised Iron Calorimeter (ICAL) detector to study the atmospheric neutrinos oscillations. About 28000 Resistive Plate Chambers (RPCs) detectors [2] of dimension 2m × 2m will be used as active element for ICAL. In view of the large number of RPC detectors required for ICAL, it is very important to perform a panoramic study of all the properties of these detectors before finalising its material and design. In this paper, we present an extensive study of optical, structural and electrical properties of different materials as appropriate electrode for RPC detector and finally we show the performance of RPC detector made with these electrodes on the basis of characterization studies.

Characterization of RPC electrodes

The RPC electrodes are usually made up of materials of high resistivity such as glass and Bakelite. We performed the bulk resistivity and surface resistivity measurements of the electrodes made up of Bakelite (namely Hylam and formica) and glasses (Asahi, Saint Gobain and Modi) to determine their electrical properties. For the purpose of determining the surface properties we performed Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) analysis. We also performed the X-Ray Diffractometry (XRD) measurement to confirm the nature (crystal or amorphous) of the materials chosen. We also studied the dependence of RPC performance under variation of enviormental temperature and humidity. From the bulk and surface resisitivity measurements, we found that the Saint Gobain glass have the maximum bulk resistivity of $15 \times 10^{12}\Omega - cm$ on an average among all the three glass electrodes, while in case of Bakelite, Hylam electrode is found to have bulk resistivity of order $\sim 10^{9}\Omega - cm$ compared to formica. Fig. 1 and Fig. 2 shows the observed bulk resisitivities for the different glass and Bakelite electrodes respectively. The surface resitivity of Asahi and Modi glass electrodes are comparable and is order of $10^{11}\Omega/\square$ are slightly greater than Saint Gobain while in case of bakelite electrodes we found almost similar results.

RPC detector performance

We made small prototype RPCs of dimension 30cm×30cm using Bakelite and glass electrode materials of thickness 3 mm. We performed the efficiency, noise rate and leakage current measurements under different enviormental temperature and gas compositions. Fig. 3 show the efficiency measurement and Fig. 4 shows the leakage current of different glass electrodes at the gas composition R134a (95%), C_4H_{10} (4.5%), SF_6(0.5%). For these measurements we had set up a muon telescope consisting of three scintillator detectors being connected with the NIM/VME Data Acquisition system (DAQ). The detector to be studied is interleaved in between the scintillator

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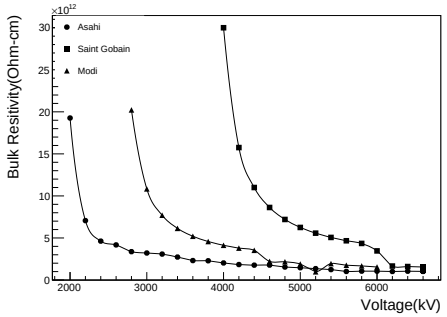

FIG. 1: Bulk resitivity measurement of different glass electrodes.

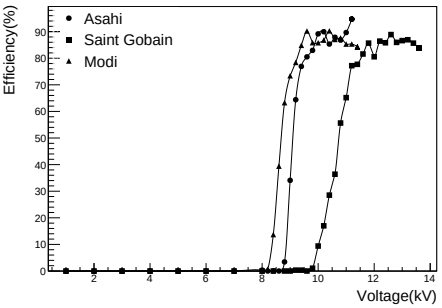

FIG. 3: Efficiency measurement of different glass electrodes.

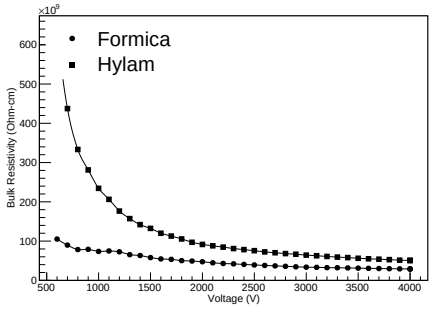

FIG. 2: Bulk resitivity measurement of different bakelite electrodes.

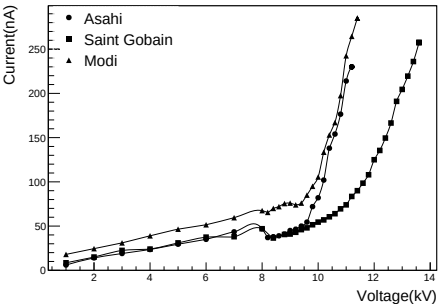

FIG. 4: Leakge Current measurement of different glass electrodes.

detector and readout by the DAQ system.

Conclusions

Chracterisation study of RPC electrodes is important for the optimum performance of INO-ICAL detector. We studied different bakelite and glass electrodes for their bulk and surface resitivities. We perform the efficiency, leakage current and noise rate of the RPCs made up of these electrodes using NIM/VME based DAQ system. We also studied the effect of temperature and humidity on the detector performance. From the performance studies, we found that Asahi and Saint Gobain glasses are best suited for INO-ICAL RPC in terms of most of parameters that we studied under given gas composition.

Acknowledgments

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References

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