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Hybrid polysiloxanes and nanocomposite scintillators for high energy and medical physics applications

Organic scintillators have found widespread use in several fields of physics as radiation sensors, owing to their peculiar chemical and physical properties. They are lightweight, easy to produce in different volumes and shapes, they commonly offer a fast response and are also tissue-equivalent in medical dosimetry. In high energy physics, these features are harnessed to collect and reveal the extremely low energy deposited by the incoming radiation by designing large volume, highly segmented calorimeters, based on organic scintillator tiles or cubes, boarding lightguides to deliver scintillation light to the far away photo-converter device. In medical physics, their classical use as X-, γ-, β- rays detectors, extensively adopted for real time delivered dose monitoring, has been recently widened to the field of proton therapy dosimetry, albeit the dependence of light output on the linear energy transfer (LET) in case of high energy protons needs to be accounted for, in order to preserve reproducibility, linearity with dose and proportionality with dose rate. Notwithstanding the assessed optimal features of commercial plastic scintillators, a lively research focused on new scintillators is ongoing to meet the requirements of future high energy experiments. In this scenario, polysiloxanes have been continuously producing new exciting shoots over the years. Their advantages over carbon based scintillators lie in the features of Si-O-Si chemical bond, which might be exploited to overcome the known limitations of plastics, such as Si-O bond strength, rotational freedom, partial ionic character. For several years we studied the properties of polysiloxane scintillator within INFN projects, probing the radiation hardness, the wavelength shifting, the neutron-gamma discrimination capabilities and the suitability for flexible dosimeters for hadrontherapy. Currently, we are working in collaboration with INFN Lecce, University of Salento and CNR Nanotec in the development of scintillators doped with perovskites and 3D printed by additive manufacturing. In the next future, different siloxanes formulations and doping methods with nanoparticles will be explored, according with the international strategy for improving the properties of timing and radiation hardness of scintillators for high energy physics. Therefore, the validation of nanostructured, dyes and/or perovskite loaded organic scintillators as for light yield, radiation resistance, dose-response correlation under high energy proton irradiation can be pursued exploiting the capabilities offered by the SPES facility. Protons with energy between 30 and 70 MeV could efficiently probe the sensing material manufactured in different shapes and volumes and their light response can be collected in situ by IBIL technique, Silicon based power meter and imaging sensors (CMOS or CCD cameras) for thorough investigation on the main features relevant for specific application in HEP and medical physics.

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