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Evaluating the suitability of organic semiconductor detectors for nuclear security

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Organic technologies are of active scientific interest due to their tuneable, scalable, and cost-effective nature. I will present radiation sensors based on organic semiconductor technology, particularly applications related to detection of hadronic radiation consisting of α radiation and thermal and fast neutrons. Neutron detection is useful in various fields, from fundamental particle and atomic physics research to the medical field and nuclear security portal monitors.

These organic sensors focus on NDI-type organic polymers including a novel material with carborane, a polyhedral cluster of carbon, boron, and hydrogen, directly incorporated in the molecular backbone (oCbT$_2$-NDI), sensitising to thermal neutrons via the boron neutron capture process. A comparison will be made with a similar polymer (PNDI(2OD)2T) with homogenously dispersed boron carbide (B_4C) nanoparticles, and a control sensor without any boron which is sensitive to more energetic fast neutrons.

Beyond this, I will present on the expansion of this technology: scaling up the size of the sensors and creating an array system synchronising multiple detectors to work together. These modes were probed for the application of making portal radiation detectors at strategic locations (ports, airports, areas of high pedestrian traffic) to identify illicit materials such as weapons grade plutonium and uranium.

The conclusion will discuss the end state of my PhD as a whole: where the project was successful, and any issues experienced. This will cover the technology readiness level at the end compared to the beginning, flaws found in the detector setups used, and outcomes of investigations probing these problems. Finally, potential future plans for the Organic Neutron Detection team at Queen Mary will be suggested in this field of organic semiconductor radiation detectors in the wake of this project.

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