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Real-time Autoradiography on Environmental Samples with a Parallel Ionization Multiplier Gaseous Detector

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Autoradiography, an imaging technique providing high resolution two-dimensional images of radioactive emissions, serves as a critical tool in the detection and monitoring of radioactivity from various samples (e.g., radiopharmaceutical, geological, environmental, etc.). For example, during the Fukushima Daiichi Nuclear Power Plant accident, phosphor screen autoradiography was employed to locate and isolate radioactive particles from air filters and regional soil [1,2]. However, this current technique is laborious, prone to error (trial and error must be used for optimal measurements), and does not provide spectrometry data. As an improvement from phosphor screen autoradiography, we propose the use of a micro-pattern gas detector (MPGD) incorporating a parallel ionization multiplier [3] to perform real-time autoradiography in environmental samples.

Real-time autoradiography with a MPGD can provide an advancement in monitoring and detection of radioactivity in complex environmental samples. With its high sensitivity (0.0005 cpm/mm^2) and activity detection range (over 5 order of magnitudes), a MPGD is advantageous in differentiating hotspots from a sample with heterogeneously distributed radioactivity. In addition, a MPGD can provide potential identification of different alpha- and beta-emitting radionuclides via spectrometry. However, this technique requires ground-truthing to ensure sensible and reliable analysis of environmental samples. In this contribution, we explore the application of a MPGD in real-time autoradiography of environmental samples in terms of the spatial resolution, sample preparation, minimum detectable activity, spectrometric capabilities, and artefact contributions. Utilizing the results from Monte Carlo simulation with a GEANT4 toolkit and experimental data from the detector (when measuring radioactive Cs-134, Cs-137, and low enriched uranium), we demonstrate that real-time autoradiography using a MPGD can reliably provide results with good reproducibility.

[1] K Adachi *et al.*, Sci. Rep. **3** (2013), 2554
[2] R Ikehara *et al.*, Environ. Sci. Technol. **52** (2018), 6390–6398
[3] J Donnard *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A **610** (2009), 158–160

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