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Towards an AI-assisted radio-geochemical lab-on-a-chip

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^{226}Ra (half-life: 1600 years) decays to form gaseous ^{222}Rn and a series of other short-lived α–emitting isotopes. Decades after the pioneering work of Marie Curie, Doerner, and Hoskins, the utilization of radium in contemporary research remains constrained to trace amounts ($<10^{-8}$ M) due to its high radioactivity (3.7×10^{10} Bq g^{-1}). What if lab-on-a-chip technology would create new opportunities, enabling work with highly radioactive elements beyond traces to access new information? In this work, we developed a lab-on-a-chip experiment paired with a computer vision pipeline to evaluate the crystal growth rate of $(Ba,Ra)SO_4$ solid solutions. Reacting solutions were injected into a microfluidic reactor where $(Ba,Ra)SO_4$ crystals were allowed to grow under different supersaturation conditions. The growth of hundreds of individual crystals was monitored by time-lapse optical microscopy. A computer vision algorithm was developed to detect different crystal habits and track changes with time, enabling an automatic determination of the crystal growth rate. Such methodology enhances experimental throughput, yielding robust statistical insights and further advancing the efficiency of such experiments. The 3D analysis of the precipitated crystals using confocal Raman spectroscopy suggested that {210} faces grew twice as fast as {001} faces, a common observation also reported for pure barite. The crystal growth rate of $(Ba_{0.5}Ra_{0.5})SO_4$ follows a second-order reaction with a kinetic constant equal to $(1.23\pm0.09) \times 10^{-10}$ mol m^{-2} s^{-1}. The lesson learned from this study marks the first building block towards an automated radio-geochemical lab-on-chip.