

Time-resolved visualization of diffusion of elements in chemical garden

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Chemical garden is a kind of soft plant-like structures grown from seed crystal of soluble metallic salts in solutions containing silicates [1]. Although it is already several centuries after the first discovery, its formation mechanism are still incompletely understood. One probable reason for such slow progress could be the lack of effective techniques for in-situ observation of the fragile structures buried in aqueous solution. In most studies, methods like visual inspection or video recording are frequently used to give descriptions of the appearance change, which are apparently far from satisfactory to offer sufficient information, especially for multi-element chemical garden experiment. On this occasion, X-ray can act as a powerful probe in observation as it can penetrate through solutions and identify different elements on the excited fluorescence, as well as it brings no external influence or destruction to the chemical garden growth. In this research, we developed a non-scanning X-ray fluorescence spectromicroscopy which uses a full-field beam from laboratory X-ray tube as light source, a micron pinhole collimator as imaging system and a commercial CCD camera as image recorder [2]. For purpose of respective imaging of different elements, the CCD camera was maintained working in single photon count mode to obtain capacity of resolving X-ray fluorescence photon energy. This microscopy was applied in the in-situ observation of multi-element chemical garden experiments. During the growth, the microscopy can record the real-time imaging results of different elements. It also supports semi-quantitative analysis of element distribution by investigating the X-ray fluorescence photon counts. As a consequence, the spread rate of different elements and the growth rate or sedimentation sequence of structures from different elements could be directly compared and clarified, which may potentially proceed the understanding of chemical garden formation mechanism.

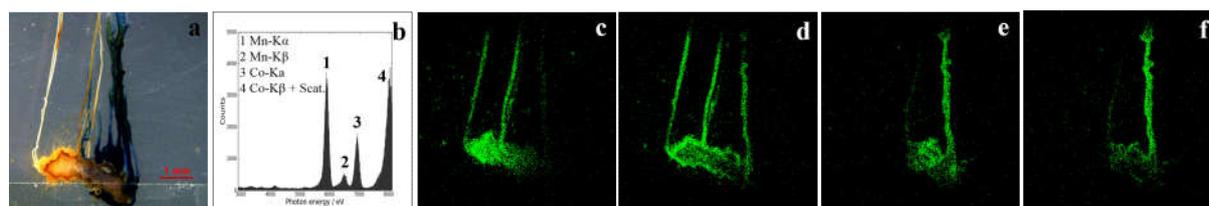


Figure 1. In-situ observation of Chemical garden growth in solution*

(a) Photo of optical microscopy, crystal seed of Mn- and Co-salt planted in sodium silicate solution; (b) X-ray fluorescence spectrum obtained over all viewing field; (c) and (d) Imaging of Mn at 0~38 min and 294~332 min, respectively; (e) and (f) Imaging of Co at 0~38 min and 294~332 min, respectively.

[1] Julyan H. E. Cartwright et al., Chemical garden formation, morphology and composition. I. effect of the nature of the cations, *Langmuir*, 2011, 27 (7): 3286.

[2] W. Zhao & K. Sakurai, X-ray fluorescence spectromicroscopy with laboratory X-ray source and CCD camera, to be submitted.

* Signal dots enhanced $\times 3$ larger to make their position more visible.