INTRODUCTION

Gallium (Ga) is an important strategic resource and has been widely used in the manufacturing of semiconductor devices (Qi et al. 2021), such as integrated circuits (Zhan et al. 2020), optoelectronics (Sutter et al. 2020), photovoltaic solar cells (Ramanujam and Singh 2017), and many modern high-tech fields, including 5G communication (Lv et al. 2019) and the Internet of Things (Yang et al. 2016). Nevertheless, in the past two decades, the enrichment of Ga was also discovered in coal, with some of them far higher than the industrial grade (30 μg·g⁻¹) (Dai et al. 2006a, 2006b, 2008, 2012; Zhou et al. 2010; Zhao et al. 2009; Wang et al. 2011; Mastalerz and Drobnia 2012; Sun et al. 2013; Qin et al. 2015; Qiao et al. 2016; Saikia et al. 2015; Shao et al. 2018). According to a rough estimate, coal deposits account for ~10 billion kg of Ga (Zhao et al. 2020), which represents almost 10 times the amount of Ga estimated in bauxite and Zn ores. However, so far, reports about Ga exploitation from coal are rare, and the yield is not high (Bielowicz 2020).

In natural systems, Ga is found primarily in a trivalent oxidation state (Schulz et al. 2017). Ga³⁺ can exist in the form of Ga(OH)₃ due to its metastability, which would spontaneously transform into α-GaOOH (Wang et al. 2011). Ga and Al have similar geochemical behavior resulting from similarities in oxidation state, amphotericity, coordination, and ionic radius (Rytuba et al. 2003). Therefore, during weathering of aluminosilicate-rich rocks (e.g., tephra and granite), they both behave as immobile ele-