

Galium merupakan logam strategis yang banyak digunakan dalam industri semikonduktor, namun ketersediaannya di alam sangat terbatas. Salah satu sumber sekunder yang menjanjikan adalah *red mud*, limbah dari industri pengolahan bauksit. Untuk mengekstraksi galium dari *red mud*, metode *Acid Leaching* menggunakan asam sulfat telah banyak dikembangkan, namun masih menghadapi tantangan rendahnya *recovery* akibat re-adsorpsi galium pada permukaan *red mud*. Penambahan surfaktan kationik *Cetyltrimethylammonium Bromide* (CTAB) dilakukan untuk meningkatkan efisiensi *leaching* galium, sekaligus mempelajari mekanisme kinetika reaksi yang terjadi selama proses tersebut.

Proses *leaching* dilakukan dengan menggunakan variasi konsentrasi asam sulfat 1; 3; dan 5M, suhu 45; 60; dan 90°C, serta penambahan surfaktan CTAB di bawah nilai *critical micelle concentration* (CMC). Rasio *solid-liquid* dijaga sebesar 10:1 dengan kecepatan pengadukan 600 rpm. *Red mud* dan residu *leaching* dikarakterisasi menggunakan XRD, XRF, FTIR, SEM-EDS, dan BET, sedangkan larutan hasil *leaching* dianalisis dengan ICP-MS. Hasil karakterisasi awal menunjukkan bahwa *red mud* mengandung Fe, Si, dan Ga berturut-turut sebesar 70,485%; 11,793%, dan 0,011%. *Recovery* maksimum *leaching* galium sebesar 83% diperoleh pada konsentrasi asam sulfat 5M, suhu 90°C, waktu 60 menit dengan penambahan surfaktan CTAB di bawah CMC. Penggunaan surfaktan CTAB mampu meningkatkan *recovery* galium sebesar 20% dibandingkan tanpa surfaktan. Pemodelan kinetika dengan pendekatan *Shrinking Core Model* (SCM) menunjukkan bahwa mekanisme pengendali adalah difusi melalui lapisan abu, dengan nilai koefisien difusi efektif (D_e) sebesar $2,7625 \times 10^{-3} \text{ m}^2/\text{s}$ tanpa surfaktan dan $6,3517 \times 10^{-3} \text{ m}^2/\text{s}$ dengan surfaktan. Studi ini membuktikan bahwa penambahan surfaktan CTAB efektif untuk meningkatkan efisiensi ekstraksi galium dari *red mud*.

Kata kunci: Galium, *red mud*, *leaching*, surfaktan CTAB, kinetika.

ABSTRACT

Gallium is a strategic metal widely used in the semiconductor industry; however, its natural availability is highly limited. One promising secondary source of gallium is red mud, a by-product of the bauxite refining industry. To extract gallium from red mud, acid leaching using sulfuric acid has been extensively developed, yet it still faces challenges of low recovery due to gallium re-adsorption onto the red mud surface. The addition of the cationic surfactant Cetyltrimethylammonium Bromide (CTAB) was applied to enhance leaching efficiency and to study the kinetic reaction mechanism during the process.

The leaching process was carried out using variations of sulfuric acid concentrations (1M, 3M, and 5M), temperatures (45°C, 60°C, and 90°C), and CTAB addition below the critical micelle concentration (CMC). The solid-to-liquid ratio was maintained at 10:1 with a stirring speed of 600 rpm. The red mud and leaching residues were characterized by XRD, XRF, FTIR, SEM-EDS, and BET, while the leachates were analysed using ICP-MS. Initial characterization results showed that the red mud contained Fe, Si, and Ga at 70.485%, 11.793%, and 0.011%, respectively. The maximum gallium leaching recovery of 83% was achieved at a sulfuric acid concentration of 5M, temperature of 90°C, and leaching time of 60 minutes with the addition of CTAB below the CMC. The use of CTAB enhanced the gallium recovery by 20% compared to leaching without surfactant. Kinetic modelling using the Shrinking Core Model (SCM) approach indicated that the controlling mechanism was diffusion through the ash layer, with effective diffusion coefficients (D_e) of $2.7625 \times 10^{-3} \text{ m}^2/\text{s}$ without surfactant and $6.3517 \times 10^{-3} \text{ m}^2/\text{s}$ with surfactant. This study demonstrates that the addition of CTAB surfactant is effective in improving the extraction efficiency of gallium from red mud.

Keywords: *Gallium, red mud, leaching, CTAB surfactant, kinetics.*