

ABSTRAK

EKSTRAKSI SILIKA GEL DARI *GEOTHERMAL BRINE* PT PERTAMINA GEOTHERMAL ENERGY TBK MENGGUNAKAN METODE *CHEMICAL PRECIPITATION (SOL-GEL)*

(Satria Ridho Illahi, 2025, 60 Halaman, 7 Tabel, 12 Gambar, dan 4 Lampiran)

Geothermal brine merupakan limbah cair hasil proses Pembangkit Listrik Tenaga Panas Bumi (PLTP) yang kaya akan kandungan mineral, salah satunya silika (SiO_2). Jika tidak dimanfaatkan, silika dalam *geothermal brine* dapat menimbulkan masalah operasional seperti *scaling* pada pipa dan turbin. Di sisi lain, silika memiliki nilai ekonomi tinggi dan banyak digunakan di berbagai sektor industri seperti kaca, keramik, elektronik, hingga farmasi. Penelitian ini bertujuan mengekstraksi silika gel dari *geothermal brine* PLTP Lumut Balai milik PT Pertamina Geothermal Energy Tbk melalui metode *chemical precipitation* (sol-gel). Proses ekstraksi dilakukan dengan variasi konsentrasi larutan NaOH (1,25%, 1,5%, 1,75%, dan 2,0%) serta variasi waktu reaksi (5, 10, 30, dan 60 menit). Ekstraksi diawali dengan pelarutan silika menjadi natrium silikat menggunakan NaOH, kemudian dilakukan presipitasi dengan penambahan HCl untuk membentuk gel. Produk silika gel yang diperoleh dianalisis berdasarkan kadar air, kapasitas adsorpsi air, pH, dan kandungan kimianya dengan *X-Ray Fluorescence* (XRF). Hasil terbaik diperoleh pada konsentrasi NaOH 1,75–2,0% dan waktu reaksi 30 menit, dengan kadar air 1,33–1,54%, kapasitas adsorpsi air 23,1–25,7%, dan pH netral (± 6). Komposisi utama silika mencapai 89,57% dengan sedikit impuritas, menunjukkan hasil ekstraksi yang cukup murni meski belum mencapai grade A. Metode sol-gel terbukti efektif dalam menghasilkan silika gel dengan kualitas baik. Penelitian ini menunjukkan bahwa limbah brine dapat diolah menjadi produk bernilai tambah, sekaligus mengurangi ketergantungan terhadap impor silika yang kian meningkat setiap tahun di Indonesia. Dengan potensi produksi hingga 4,49 ton/jam dari kandungan silika dalam brine PLTP Lumut Balai, pendekatan ini sangat prospektif untuk dikembangkan lebih lanjut dalam skala industri guna mendukung ekonomi sirkular dan keberlanjutan energi panas bumi.

Kata Kunci: Silika Gel, Geothermal Brine, Sol-Gel, Presipitasi Kimia, Ekstraksi Silika

ABSTRACT

EXTRACTION OF SILICA GEL FROM GEOTHERMAL BRINE OF PT PERTAMINA GEOTHERMAL ENERGY TBK USING CHEMICAL PRECIPITATION (SOL-GEL) METHOD

(Satria Ridho Illahi, 2025, 60 Pages, 7 Tables, 12 Figures, and 4 Appendices)

Geothermal brine is a by-product of geothermal power plants rich in dissolved minerals, including silica (SiO_2). If left untreated, silica in brine can cause operational issues such as scaling in pipes and turbines. However, silica holds high economic value and is widely used across industries such as glass, ceramics, electronics, and pharmaceuticals. This study aims to extract silica gel from geothermal brine from the Lumut Balai geothermal power plant operated by PT Pertamina Geothermal Energy Tbk using the chemical precipitation (sol-gel) method. The extraction process involved varying NaOH concentrations (1.25%, 1.5%, 1.75%, and 2.0%) and reaction times (5, 10, 30, and 60 minutes). Initially, silica was dissolved into sodium silicate using NaOH, followed by precipitation with HCl to form gel. The resulting silica gel was analyzed based on moisture content, water adsorption capacity, pH, and chemical composition using X-Ray Fluorescence (XRF). The optimal condition was found at 1.75–2.0% NaOH concentration and 30-minute reaction time, yielding a moisture content of 1.33–1.54%, adsorption capacity of 23.1–25.7%, and neutral pH (~6). The silica content reached up to 89.57%, indicating a high purity level, although not yet meeting grade A based on Indonesian National Standards (SNI). The sol-gel method proved to be an effective approach to produce quality silica gel. This study highlights that geothermal brine, often regarded as waste, can be converted into high-value materials, reducing dependency on imported silica, which continues to rise annually in Indonesia. With an estimated 4.49 tons/hour of extractable silica from Lumut Balai's brine, this approach is highly promising for industrial-scale development, supporting circular economy initiatives and sustainable geothermal energy utilization.

Keywords: Silica Gel, Geothermal Brine, Sol-Gel, Chemical Precipitation, Silica Extraction