

**SINTESIS DAN KARAKTERISASI DES TERNER
BERBASIS KOLIN KLORIDA DAN APLIKASINYA DALAM PELINDIAN
LOGAM PERAK DARI LIMBAH *PRINTED CIRCUIT BOARD***

SKRIPSI

diajukan untuk memenuhi sebagian syarat untuk memperoleh gelar
Sarjana Sains Program Studi Kimia



oleh

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FAKULTAS PENDIDIKAN MATEMATIKA DAN ILMU PENGETAHUAN ALAM
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BANDUNG
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LEMBAR HAK CIPTA

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Sebuah skripsi yang diajukan untuk memenuhi sebagian syarat memperoleh gelar Sarjana Sains pada Program Studi Kimia, Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam.

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Agustus 2024

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PERNYATAAN

Dengan ini saya menyatakan bahwa skripsi dengan judul “Sintesis dan Karakterisasi DES Terner Berbasis Kolin Klorida dan Aplikasinya dalam Pelindian Logam Perak dari Limbah *Printed Circuit Board*” ini beserta seluruh isinya adalah benar-benar karya saya sendiri. Saya tidak melakukan penjiplakan atau pengutipan dengan cara-cara yang tidak sesuai dengan etika ilmu yang berlaku dalam masyarakat keilmuan. Atas pernyataan ini, saya siap menanggung risiko/sanksi apabila di kemudian hari ditemukan adanya pelanggaran etika keilmuan atau ada klaim dari pihak lain terhadap keaslian karya saya ini.

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Yang membuat pernyataan,



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ABSTRAK

Perkembangan teknologi pesat telah mendorong percepatan siklus pergantian perangkat elektronik, membuat jumlah limbah elektronik meningkat. Papan sirkuit cetak (PCB) mengandung berbagai logam bernilai mendominasi jumlah limbah elektronik. Dalam upaya pungut ulang logam yang ramah lingkungan, metode solvometalurgi menggunakan *deep eutectic solvent* (DES) dapat diterapkan. Tujuan penelitian adalah untuk mengembangkan DES terner berbasis HBA kolin klorida dengan komponen HBD etilen glikol–asam sitrat (TDES 1) dan asam oksalat–asam sitrat (TDES 2), untuk pelindian logam perak. Metode penelitian diawali dengan sintesis untuk memperoleh rasio molar TDES terbaik, mempreparasi sampel WPCB, menguji sifat fisik dan FTIR, dan melakukan aplikasi pelindian terhadap sampel WPCB. Hasil optimasi rasio molar menunjukkan rasio terbaik TDES 1 adalah 2:3:1 dan TDES 2 adalah 4:1:1. Uji kelarutan mengindikasikan kedua TDES bersifat polar. Nilai pH TDES 2 teramati lebih asam (0–1) dibandingkan TDES 1 (1,2020). TDES 1 dan 2 memiliki densitas masing-masing sebesar 1,2524 dan 1,2695 g/cm³. Analisis FTIR mengindikasikan adanya pembentukan ikatan hidrogen, dari pelebaran dan pergeseran daerah 3.000–3.400 cm⁻¹. TDES 1 dan TDES 2 diaplikasikan dalam pelindian WPCB pada kondisi 120 °C, 16 jam, 500 rpm, *solid/liquid ratio* (S/L) 1/20 g/mL. Sampel awal WPCB diketahui mengandung 1,60% logam perak. Kinerja pelindian WPCB menunjukkan nilai persen pelindian logam perak TDES 1 lebih besar yaitu 76,85%, dibandingkan 48,38% untuk TDES 2. Hal tersebut dapat disebabkan viskositas TDES 2 yang terlalu tinggi. Maka, dapat disimpulkan bahwa TDES 1 memiliki kinerja pelindian lebih tinggi untuk logam perak pada kondisi pelindian yang sama. DES terner dapat digunakan sebagai pelarut pelindian logam berharga dari sumber sekunder berpotensi menjadi solusi untuk penurunan cadangan material global dan mendukung pencapaian Tujuan Pembangunan Berkelanjutan (SDGs).

Kata kunci: DES terner, kolin klorida, logam perak, pelindian, *printed circuit board*.

ABSTRACT

Rapid technological developments have accelerated the replacement cycle of electronic devices, increasing the amount of electronic waste. Printed circuit boards (PCBs) containing various valuable metals dominate the amount of electronic waste. The solvometallurgy method, which uses deep eutectic solvent (DES), can be applied to recover environmentally friendly metals. The purpose of this study was to develop a ternary DES based on HBA choline chloride with HBD components ethylene glycol–citric acid (TDES 1) and oxalic acid–citric acid (TDES 2), for leaching silver metal. The research method began with synthesis to obtain the best TDES molar ratio, preparing WPCB samples, testing physical properties and FTIR, and conducting leaching applications on WPCB samples. The results of the molar ratio optimization showed that the best ratio of TDES 1 was 2:3:1 and TDES 2 was 4:1:1. Solubility tests indicated that both TDES were polar. The pH value of TDES 2 was observed to be more acidic (0–1) than TDES 1 (1.2020). TDES 1 and 2 have densities of 1.2524 and 1.2695 g/cm³, respectively. FTIR analysis indicated the formation of hydrogen bonds, from the broadening and shifting of the 3,000–3,400 cm⁻¹ region. TDES 1 and TDES 2 were applied in WPCB leaching at 120 °C, 16 hours, 500 rpm, solid/liquid ratio (S/L) 1/20 g/mL. The initial WPCB sample was known to contain 1.60% silver metal. The WPCB leaching performance showed a higher percentage of silver metal leaching value of TDES 1, 76.85%, compared to 48.38% for TDES 2. This could be due to the viscosity of TDES 2 being too high. Therefore, it can be concluded that TDES 1 has a higher leaching performance for silver metal at the same leaching conditions. Ternary DES can be used as a solvent for leaching valuable metals from secondary sources, potentially becoming a solution for the decline in global material reserves and supporting the achievement of Sustainable Development Goals (SDGs).

Keywords: *choline chloride, silver metal, leaching, printed circuit board, ternary DES*

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