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A novel desulfurization process of gasoline via sodium metaborate electroreduction with pulse voltage using a boron-doped diamond thin film electrode

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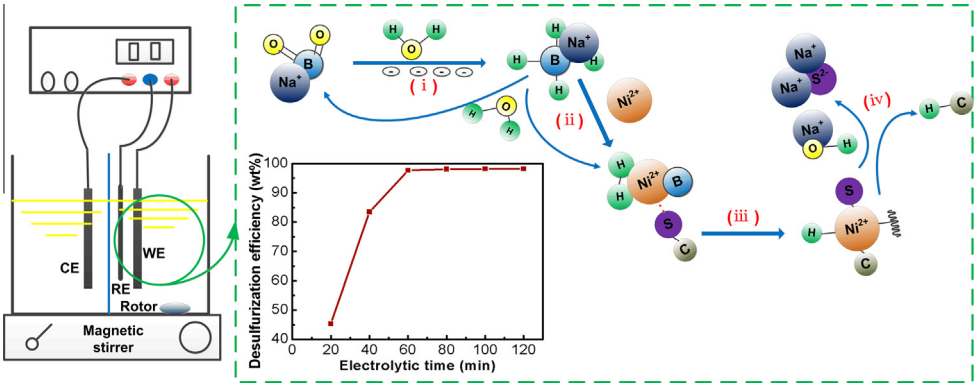
HIGHLIGHTS

- $NaBH_4$ was obtained via $NaBO_2$ electroreduction with pulse voltage using BDD electrodes.
- The factors that influenced desulfurization efficiency were investigated.
- Possible desulfurization mechanism was proposed.
- Desulfurization kinetics showed a pseudo-first-order toward thiophene or benzothiophene.
- The novel gasoline desulfurization process under mild conditions was feasible.

GRAPHICAL ABSTRACT



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ABSTRACT

A novel desulfurization process of gasoline was realized via sodium metaborate ($NaBO_2$) electroreduction with pulse voltage using a boron-doped diamond (BDD) thin film electrode under mild conditions. The results of cyclic voltammetry and ^{11}boron (B) nuclear magnetic resonance (NMR) confirmed that $NaBO_2$ was converted into sodium borohydride ($NaBH_4$) by electroreduction and the electroreduction voltage ranged from −1.2 V to −1.8 V. The factors that influenced desulfurization efficiency were investigated and the desulfurization efficiency reached more than 95% for model gasoline and more than 97% for real gasoline. The components of model gasolines before and after desulfurization were analyzed by gas chromatography/mass spectrometer (GC/MS) and the elements content of electrolytes and digestion solution of precipitate were determined by inductively coupled plasma (ICP). Results indicated that reductive desulfurization process mainly involved the cleavage of C–S bond and the hydrogenation of C–C double bond and B recycle was realized at the same time as desulfurization. Consequently, possible desulfurization mechanism was proposed. Desulfurization kinetics showed a pseudo-first-order toward thiophene or benzothiophene. All these results indicated that the gasoline desulfurization process via sodium metaborate electroreduction with pulse voltage using a BDD thin film electrode was feasible.

1. Introduction

Increasingly stringent environmental regulations have been applied in many countries to reduce the sulfur levels in fuel [1]. Zero-emission and zero-levels of sulfur content are previewed in the near future [2]. A basic method for removal of sulfur from gasoline is catalytic hydrodesulfurization (HDS). However, it needs high investment, operating costs and suffers from significant loss in the octane number caused by saturation of olefins [3]. Therefore, more efforts have been made to develop novel non-HDS methods such as alkylation [4,5], extraction [6–8], oxidation/extraction

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