Journal of Power Sources 248 (2014) 317–322

Contents lists available at ScienceDirect

Journal of Power Sources

journal homepage: www.elsevier.com/locate/jpowsour

Short communication

A novel boost circuit design and in situ electricity application for elemental sulfur recovery

Jia Liu, Yujie Feng*, Weihua He, Yuanyuan Gong, Youpeng Qu, Nanqi Ren

State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology, No 73 Huanghe Road, Nangang District, Harbin 150090, China

HIGHLIGHTS

- A novel microbial electrochemical system (MES) was designed for electricity generation and sulfate conversion.
- Both electrical energy boosting and in situ utilization were achieved by using novel boost circuit.
- Elemental sulfur can be recovered from an electrochemical deposition cell (ECD) without any net energy input.

ARTICLE INFO

Article history:
Received 28 June 2013
Received in revised form
1 September 2013
Accepted 23 September 2013
Available online 2 October 2013

Keywords:
Microbial electrochemical system
Novel boost circuit
Elemental sulfur recovery
In-situ energy utilization

ABSTRACT

A novel system containing a microbial electrochemical system (MES) for electricity generation and sulfate conversion, a novel boost circuit (NBC) for in situ utilization of the electrical energy and an electrochemical deposition cell (ECD) to recover sulfur in water is designed and established. This combined system has a higher energy utilization efficiency of 63.6% than that of conventional sulfate reduction reactors with an elemental sulfur recovery efficiency up to 46.5 ± 1.5% without net energy input. This system offers a promising, and cost-effective approach for sulfate wastewater treatment.

1. Introduction

Sulfate contamination is present in a wide range of both industrial wastewaters and sewage such as mining, tannery, food processing, paper mill wastewaters etc [1,2]. In wastewater treatment plant (WWTP), sulfate compounds were usually converted to sulfide or hydrogen sulfide by sulfate-reducing bacteria (SRB) under anaerobic conditions of wastewater treatment process and released to air, causing secondary pollution [3]. These compounds emission are associated with several important deterioration problems for aquatic ecosystems, including release of unpleasant odors, pose a potential risk to human health and induce corrosion to architectures, metals etc [4,5]. So, the removal of sulfate from wastewaters and recovery of elemental sulfur are two key challenges that researchers should be faced with.

Sulfate can be removed by physico-chemical methods, but high operation cost and post-treatment of large quantities of sludge restrained the utilization of physico-chemical technologies to collect sulfur [3]. During biological removal process, sulfate is usually converted to sulfide coupling with COD removal by strains of sulfate-reducing bacteria (SRB). Elemental sulfur might be further collected by strains of sulfur-oxidizing bacteria (SOB) [6]. However, it is difficult to separate the elemental sulfur from activated sludge although the activities of both SRB and SOB are high in practical WWTP [7]. Moreover, both high running cost (€ 1.9 to 7.2 kg^{-1} S removal), low energy utilization efficiency (10%–25%) and low sulfate removal rate (26.4%–52.9%) are a major bottleneck for the existing sulfate removal technologies [3,8–10].

The electrochemical deposition of sulfide can be used to recover pure elemental sulfur on the surface of electrode [11]. It offers very beneficial alternative and promising approach to improve recovery efficiencies of elemental sulfur and enable the development of new processes to minimize by-products and large scale production [1,12]. But the major limitation of the

* Corresponding author. Tel./fax: +86 451 86287017.
E-mail address: yujief@hit.edu.cn (Y. Feng).

0378-7753/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jpowsour.2013.09.098

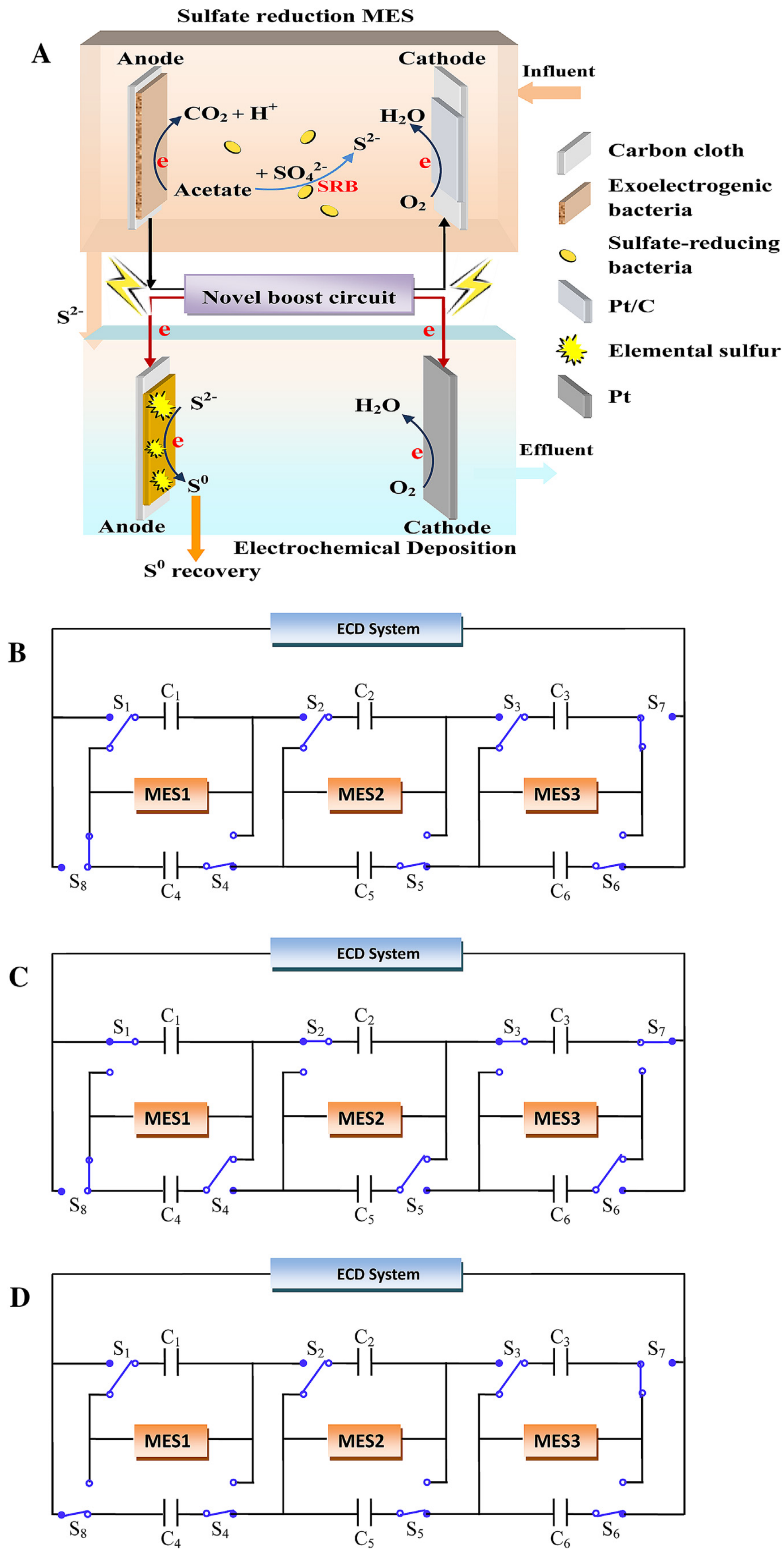

Fig. 1. The schematic (A) and circuitry diagrams of in-situ energy-harvesting and utilization based alternate charging and discharging of both sulfate reduction MESs and electrochemical deposition system: (B) charging of C_1–C_3 by MES1–MES3, (C) discharging of C_1–C_3 capacitors in series and charging of C_4–C_6 by MES1–MES3, (D) discharging of C_4–C_6 capacitors in series and charging of C_1–C_3 (MES1, MES2, MES3, sulfate reduction MESs; ECD system, electrochemical deposition system; C_1–C_6, external capacitors; S_1–S_8, relay switches).