

## Promoting effect of potassium addition to calcined scallop shell supported catalysts for the decomposition of tar derived from different biomass resources

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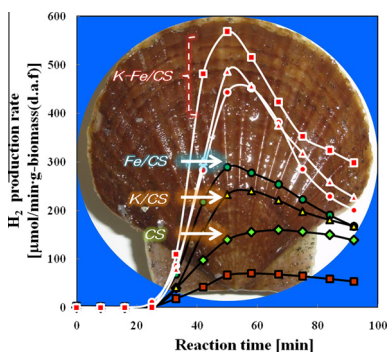
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### HIGHLIGHTS

- Catalytic performances of calcined shell supported catalysts were investigated.
- Promoting effect of K addition in the catalyst for the steam reforming of tar was clarified.
- Effects of reaction temperature and concentration of catalyst loading on the performance of catalyst were identified.

### GRAPHICAL ABSTRACT



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### ABSTRACT

Decomposition of tar derived from 4 biomass resources, i.e., cellulose, lignin (alkaline and dealkaline), pruned apple branch (PAB) and rice straw over calcined scallop shell (CS) and iron(Fe)-loaded CS were performed in a fixed bed reactor at different temperatures. It was found that alkali species such as potassium in the biomass could migrate to the surface of catalyst with the tar, and hence promote catalytic activity of the regenerated catalyst. In order to reveal this phenomenon, in this study a small amount of K was doped on CS and Fe-loaded CS and applied in the steam reforming of tar derived from cellulose and dealkaline lignin. The results indicated that the addition of K greatly enhanced hydrogen production rate.

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### 1. Introduction

Removal and/or conversion of tar to synthetic gases (syngas) are a crucial step in the development of biomass gasification technologies. The tar derived from biomass gasification is a highly thermally stable condensable mixture of diverse substances with

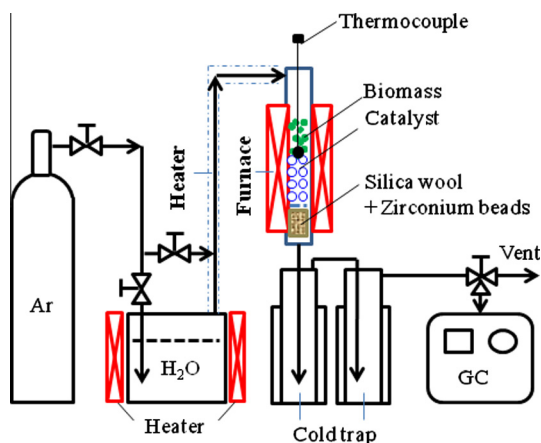
complex ring structures at room temperature. It usually causes corrosion and plugging problems in the equipments of gas purification processes, engines, and turbines [1–4]. However, subsequent conversion of tar to a fuel gas or syngas by a thermochemical method can improve the overall gasification efficiency. To date, various methods have been developed for the thermal cracking and reforming of tar [5–7]. In order to decrease the treatment temperature, catalytic steam reforming process is generally adopted. Natural mineral catalysts, such as dolomite, olivine and calcined

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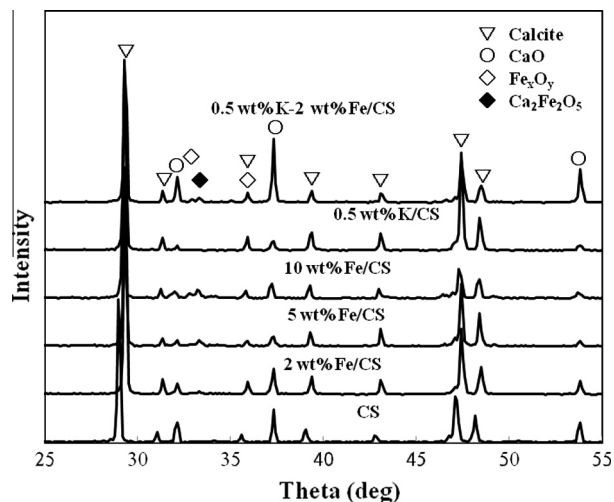
**Table 1**  
Mass balance of biomass heated at 610 °C for 2 h in argon gas.

Biomass	Temperature	Volatiles (including H <sub>2</sub> O)	Char + ash
PBA	610	79.56	23.44
Rice straw	610	59.28	40.72
Cellulose	610	88.68	11.32
Alkaline lignin	610	69.33	30.67
Dealkaline lignin	610	63.42	36.58



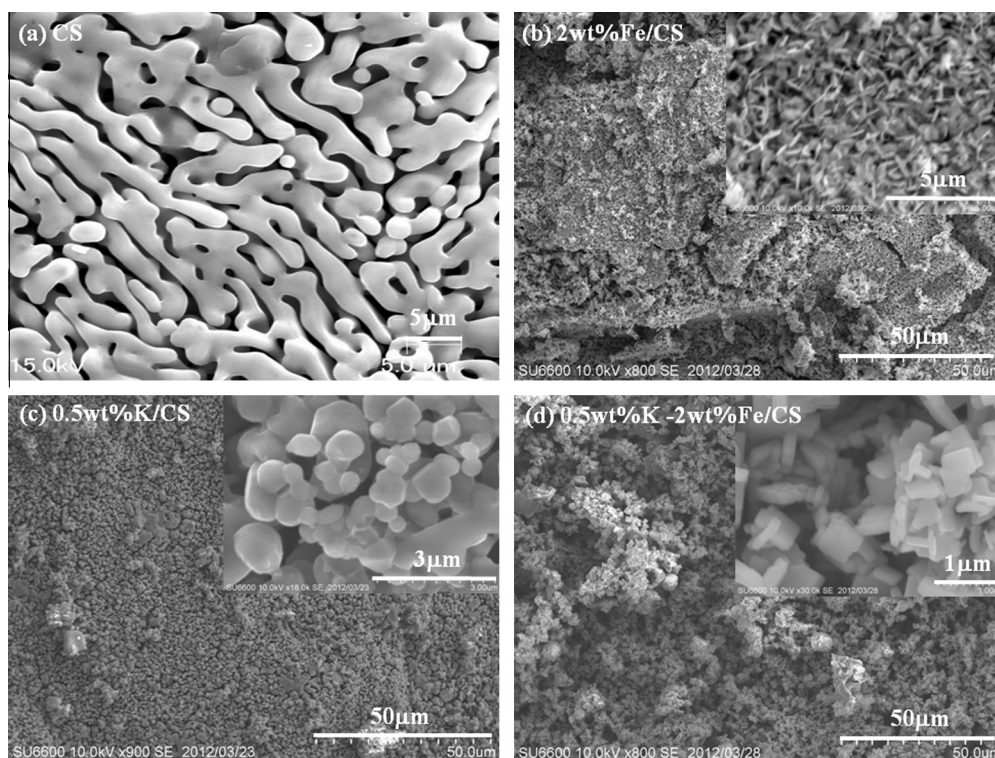
**Fig. 1.** Schematic diagram of the experimental set-up for steam reforming reaction.

shells, and metal (mainly Pt, Rh, Fe, Co, Ni, La.) doped on the above natural minerals as well as unnatural supports such as Al<sub>2</sub>O<sub>3</sub>, MgO and SiO<sub>2</sub> have been tested for the tar reforming [8–21]. Alkali and alkaline earth metals (AAEM) such as Ca, Mg, K, and Na have been found to accelerate the pyrolysis and/or the gasification of biomass [22,23]. Direct impregnation of various potassium compounds



**Fig. 3.** XRD patterns of as-prepared catalysts.

such as K<sub>2</sub>CO<sub>3</sub>, CH<sub>3</sub>COOK, KOH and KCl to biomass can lower the decomposition temperatures and enhance the yields of gaseous products [24–26]. Especially, it is found that potassium has a distinguished catalytic effect in promoting the formation of low molecular weight compounds [27]. However, only a few studies have focused on the effect of AAEM species on the decomposition of tar derived from biomass. The AAEM species in the biomass tend to volatilize during the pyrolysis and condense with the produced tar [23]. Therefore, AAEM species should be retained in the tar derived from original biomass, and have some effects on the catalytic activity of the catalyst used for the decomposition of tar. On the other hand, it should be noted that different biomass contains different amounts of AAEM species, resulting in different release properties during pyrolysis [28]. In our previous study [12], one



**Fig. 2.** SEM images of as-prepared catalyst.

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