# O-10

## Basic study on steam gasification of epoxy board in the presence of molten eutectic carbonates

○ Shangzhong ZHANG[1], Dongchun JIN[2], Hideki NAKAGOME[2], Tomoaki NAMIOKA[1],
Kunio YOSHIKAWA[1], Tohru KAMO[3]
[1]Tokyo Institute of Technology; [2]Chiba University;
[3]National Institute of Advanced Industrial Science and Technology (AIST)

Steam gasification of epoxy board was carried out in molten eutectic carbonates ($Li_2CO_3$, $Na_2CO_3$, $K_2CO_3$). The influences of reaction temperature, steam partial pressure, steam flow rate, and particle size were studied . These experimental results indicated that the eutectic molten carbonates accelerate steam gasification of the epoxy board at 600-700$^0$C under atmospheric pressure.

*Key words:* E-waste; Steam gasification; Epoxy board; Lithium; Sodium; Potassium, Carbonates

### 1. Introduce

Recovering useful metals from e-waste is important not only for protecting global environment, but also for securing strategic materials essential to the electronic industry (1), (2). Especially developing economical and environmental friendly technology has been expected eagerly, because the e-waste contains a lot of valuable materials and toxic metals. In order to realize high-rate-recycling of the e-waste and low-level-pollution caused by recycling, new environmental regulations and social systems have been established in many countries (3), (4).

In this study, steam gasification of glass-fiber-reinforced epoxy board was carried out in the presence of eutectic carbonates. Effect of the eutectic carbonate, temperature, steam partial pressure, and sample particle size was investigated to recover useful metals and to convert plastics into hydrogen effectively.

### 2. Experimental

#### 2.1 Samples

Glass fiber reinforced epoxy board (EL-3762, Hitachi Chemical Company) was used as a model material of practical waste circuit board. The low melting point eutectic carbonate was prepared by mixing equal weight of three carbonates, (Lithium carbonate, sodium carbonate, and potassium carbonate, Wako Pure Chemical Industries, Ltd.) (5).

#### 2.2 Experimental procedure

Schematic outline of the experimental apparatus is shown in Fig.1. The equipment was composed of the sample feeding, the reactor (ID: 32 mm, L: 125 mm), the heater, the steam generator, the gaseous products cooling system, and the gas analyzing system. Nitrogen gas (40~100 cm$^3$/min) and ultra pure water (0.2~1.3 g/min) were introduced into the reactor through a pre-heater. Epoxy sample (0.5 g) was fed into the reactor through a tube after temperature of the reactor reached to the designated value. Physical contact efficiency between solid sample pieces and molten eutectic carbonate was improved by blowing of gaseous steam and nitrogen gas. Composition of the gaseous product was analyzed by the rapid gas chromatography (Varian CP-4900) and the flow rate of the gas was measured by an integrating flow meter.

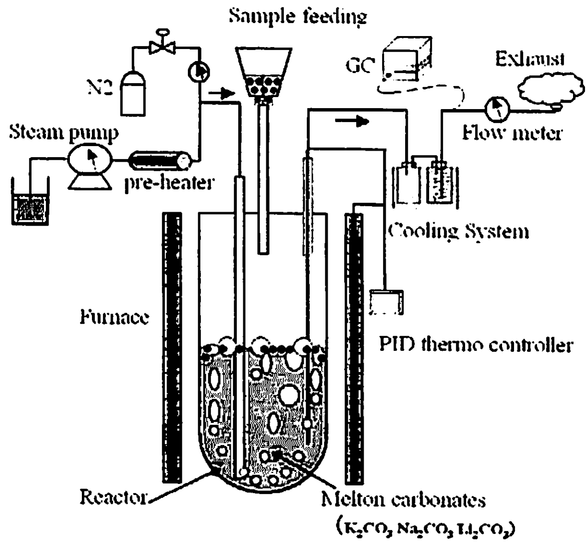


Fig.1 Experimental apparatus

### 3. Results and discussion

Hydrogen was produced mainly, and trace amount of methane and ethane were detected. In the absence of carbonate, carbon dioxide was detected as a main product as well as hydrogen. However, carbon dioxide directly derived from steam gasification of epoxy was hardly detected, because carbon dioxide from epoxy was hidden in a lot of carbon dioxide produced from hydrolysis of carbonate. Rates of hydrogen formation at the presence of eutectic carbonate or in the absence of carbonate were shown in Fig.2. These experimental results indicate that the carbonate have an acceleration effect on the steam gasification of the epoxy board.

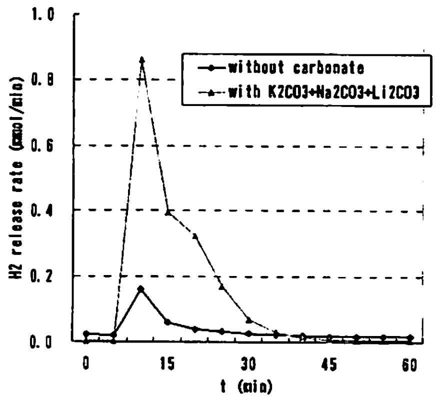


Fig.2 The effect of carbonate on hydrogen generation. $V_{N2}$=40ml/min, $V_{steam}$=320ml/min, T=675$^0$C, $P_{total}$=0.1Mpa, $W_{sample}$=0.5g(10pcs), $W_{carbonate}$=30g

Effect of particle size on the rate of steam gasification was shown in Fig.3. Logarithmic value of hydrogen formation rate decreased lineally with the reaction time. Slopes of the lines show the steam gasification rate by using the assumption of the pseudo-first-order reaction. Increase of the steam gasification rate by pulverizing of sample particles implies that mechanical contact of solid samples to molten carbonate or gaseous steam is very important.

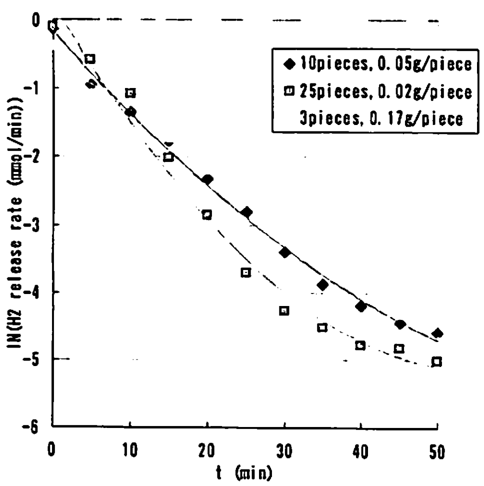


Fig.3 The effect of partical size on hydrogen generation. $V_{N2}$=40ml/min, $V_{steam}$=320ml/min, T=675$^0$C, $P_{total}$=0.1Mpa, $W_{sample}$=0.5g, $W_{carbonate}$=30g

The steam gasification rate of the epoxy sample increased with the reaction temperature. Arrhenius plot of the rate of hydrogen formation by steam gasification was a straight line such as shown in Fig. 4. Activation energy of steam gasification of the epoxy sample in the presence of eutectic carbonate was calculated as 334 kJ/mol from the slope of the Arrhenius slot. The activation energy of the steam gasification observed in the presence of carbonate was slightly lower than that which was measured without carbonate. The experimental results suggest that eutectic carbonate accelerate the steam gasification as a catalyst.

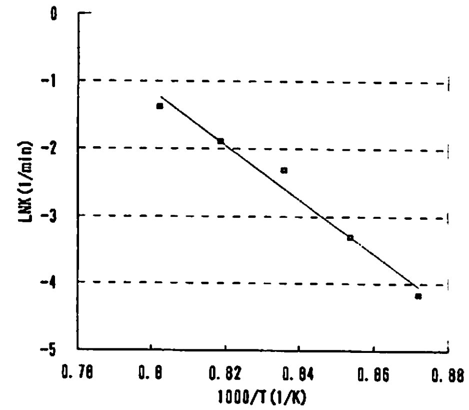


Fig.4 Arrhenius plot of the rate of hydrogen formation by steam gasification

4. Conclusion

Hydrogen was observed as a main product of the steam gasification of epoxy board. The ternary eutectic carbonates ($Li_2CO_3$, $Na_2CO_3$, $K_2CO_3$) accelerated steam gasification of the epoxy board at 600-700$^0$C under atmospheric pressure. We can conclude that steam gasification is effective method to remove plastic parts and to recovery useful metals in the e-waste.

Reference


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