GAS PRODUCTION BY STEAM GASIFICATION OF POLYPROPYLENE/BIOMASS WASTE COMPOSITES IN A DUAL-BED REACTOR

Md. Azhar Uddin*[1], Taichi Watanabe[1], Yoshiei Kato[1],
Elena Parparita[2], Cornelia Vasile[2], Jale Yanik[3]

[1] Department of Energy and Materials, Okayama University, Okayama, Japan.
[2] Petru Poni Institute of Macro Molecular Chemistry, Iasi, Romania.
[3] Department Of Chemistry, EGE University, Izmir, Turkey
e-mail: alazhar@cc.okayama-u.ac.jp; phone & fax: +81-86-251-8897

Abstract

Polypropylene/biomass waste composites were tested by steam gasification in a dual-bed microreactor in a two-stage process for the production of fuel gases. Gasification experiments were carried out at different gasification temperatures, in absence and presence of Fe_2O_3/CeO_2 catalysts. The gases produced during the process were mainly H_2, CO, CO_2, CH_4 and some higher hydrocarbons.

Keywords: *polypropylene, biomass composites, gasification.*

1. Introduction

Many developed countries are dealing with serious sustainability problems, especially concerning energy needs and waste handling. Plastic wastes are of great importance due to the increase of their production in recent years and waste plastics are also valuable source of materials and energy when utilized properly. Biomass has lately attracted considerable attention as a source of clean fuel and energy. Gasification is a technology for converting carbonaceous materials such as coal, biomass, and waste plastics into gaseous fuel. Studies on co-gasification of plastic with other materials like coal or biomass have been reported that the gaseous products with high hydrogen content can be obtained by steam gasification [1]. However, the gasification efficiency depends on the operating conditions, reactor types and the use of reaction promoting materials such as catalysts. The goal of this work is to study the steam gasification of polypropylene/biomass wastes composites in a dual bed reactor in presence and absence of catalyst in order to investigate the effectiveness of catalyst in the production of fuel gases.

2. Materials and Methods

The biomass and plastics samples studied in this work were Brassica rapa (BR), Eucalyptus globulus (EG), Energy grass (EnG), Pine cones (PC) and polypropylene (PP). The composites containing polypropylene (PP) 70 wt % and biomass 30 wt % were obtained by melt blending at 175 °C in the chamber of a Brabender mixer. The steam gasification experiments of the samples were carried out in a dual bed quartz reactor with top bed temperature at 200-850 °C (programmed: 3 °C/min) and the bottom bed temperature at 700 °C. In a typical run, 0.04g of sample was placed in the top section on a quartz wool bed and the desired amount (0.065ml) of 10% Fe_2O_3/90%CeO_2 catalyst was placed on the bottom quartz wool bed. Gasification experiments were carried out in absence and presence of catalyst at 700 °C and 750 °C. Fig. 1 shows the scheme of the steam gasification experiment.

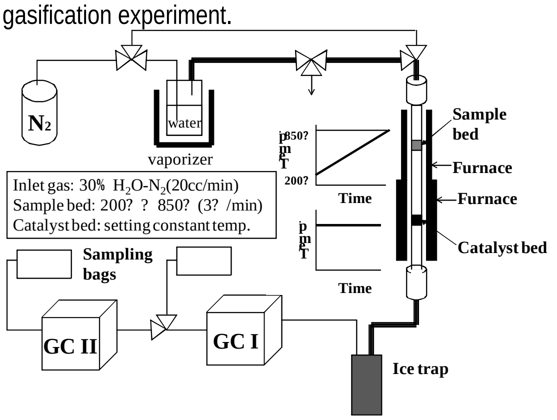

Fig.1 Diagram of steam gasification set up

3. Results and discussion

Figure 1 and 2 shows the amount of gases produced during steam gasification of PP, BR, EG, EnG, PC, PP/BR, PP/EG, PP/EnG and PP/PC composites at 700°C in the bottom bed temperature without catalysts (a) and with catalyst (b). During steam gasification of the PP and biomass samples, CO, CO_2, C_1-C_4 hydro carbons and hydrogen were produced as gaseous products. Degradation of PP produces mainly H_2, CH_4 and C_2-C_4, while the biomass BR, EG, EnG and PC produces mainly H_2, CO and CO_2. The use of 10% Fe_2O_3/90%CeO_2

catalyst in the steam gasification of biomass, plastics and biomass/plastic composites resulted in the increase in production of gaseous products indicating that the catalyst accelerated the gasification rate. Particularly the production of H_2 and CO_2 increased significantly which could be attributed to the effect of catalyst in water gas shift reaction of CO ($CO + H_2O \Leftrightarrow H_2 + CO_2$).

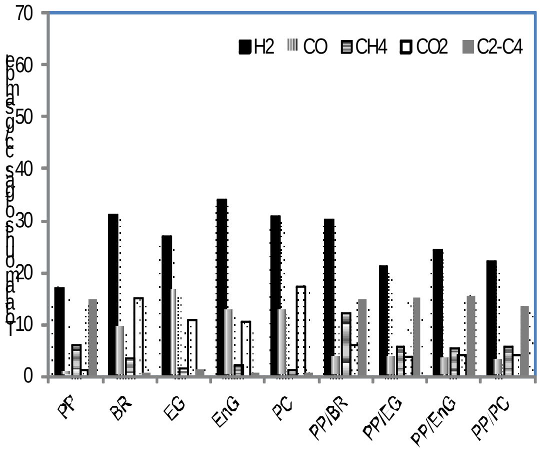

Fig. 1 Thermal steam gasification of PP, biomass and PP/biomass composites

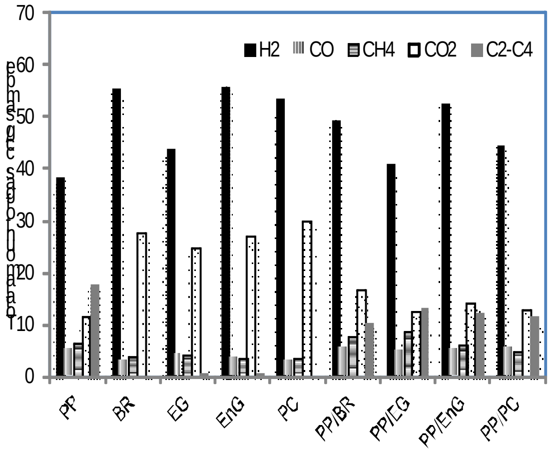

Fig. 2 Effect of catalyst on the production of gaseous products at 700 °C for the steam gasification of biomass and biomass/PP composites

Moreover, the synergistic effect of combining plastics with biomass was also observed since the amount of H_2 production increased in the case of PP/biomass composites compared to the added contribution of production of H_2 from the individual components (Table 1). This synergistic effect may be resulted from the interaction of the degradation products of the plastics and biomass gasification.

Table 1. Synergistic effect of biomass and PP gasification at 700°C

	Amount of gas production (cc)							
	PP/BR		PP/EG		PP/EnG		PP/PC	
	Calc.[a]	Exp.[b]	Calc.[a]	Exp.[b]	Calc.[a]	Exp.[b]	Calc.[a]	Exp.[b]
H_2	43.59	49.53	40.07	41	43.65	52.59	42.94	44.59
CO	4.65	5.59	5.01	5.09	4.81	5.16	4.63	5.63
CH_4	5.78	7.86	5.83	8.95	5.67	6.25	5.70	4.99
CO_2	16.52	16.82	15.67	12.50	16.28	14.31	17.17	12.9
C_2-C_4	12.74	10.58	12.8	13.44	12.76	12.49	12.70	11.94

[a] Calculated by adding the contribution of gasification products of individual components.

[b] Obtained from co-gasification of PP/biomass composites.

References

1. F. Pinto, C. Franco, R. N. André, M. Miranda, I. Gulyurtlu and I. Cabrita. *Fuel* 81 (2002) 291-297.