INVESTIGATION OF THE INTRINSIC RATE OF THE GASIFICATION OF BIOMASS CHARS

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Introduction

As biomass represents a renewable energy and carbon source, the reaction rate during the gasification of biomass chars with carbon dioxide is investigated. This investigation focuses on the estimation of reaction conditions to avoid heat and mass transfer and the determination of the reactive surface area of the biomass chars as a function of conversion degree [1,2,3]. The reactive surface area is calculated from the amount of desorbed carbon oxides during temperature programmed desorption studies (TPD) [2,4]. The aim of this investigation is to find out, if the reactive surface area can be applied to describe the relevant surface during gasification.

Experimental

The experiments are done on two biomass chars derived from beech wood and oil palm shell. Each biomass is heated to 1123 K with a heating rate of 3 K/min and a soaking time of 30 minutes. After naturally cooling, the chars are ground and sieved. Desorption studies are made with the surface analyser TPD/R/O 1100 from ThermoQuest. The determination of the reactive surface area by temperature programmed desorption requires the calculation of the total and the stable active surface area

$$[\text{reactive C-O}]=[\text{total C-O}]-[\text{stable C-O}].$$

A typical TPD experiment begins with in situ partial gasification of the char in the gasifying agent. After reaching the desired conversion degree, the sample (100 mg) is quenched in reactant gas to a temperature at which no siginificant gasification occurred. The reactant gas is then flushed from the system with argon. Once the concentration of carbon monoxide and carbon dioxide returns to baseline levels, the sample is heated at a constant heating rate of 3 K/min to a final temperature of 1173 K. This temperature is held for 2 h, to achieve complete desorption of carbon monoxide and carbon dioxide from the char surface. From the desorbed amount of carbon oxides, the total active surface area is calculated. The TPD procedure was modified to allow a direct determination of the amount of stable carbon oxides formed on the char surface after partial gasifcation in the reactant gas. After gasification to a specified degree of conversion, a flow of argon is permitted to flow over the sample to desorb the reactive intermediate formed during gasification. Once the concentration of carbon oxides

reached its baseline level, the char is quenched in argon to a temperature at which no gasification is expected. Beginning at this temperature, a TPD experiment, as previously described, is performed. For gas analysis, a mass spectrometer was used. Beech wood and oil palm shell char are gasified at 1023 K and 1053 K, respectively. The partial pressure of carbon dioxide is 100 kPa. Particle sizes up to 125 μm are chosen.

Results and Discussion

Typical TPD spectra for the determination of the total and stable active surface area are shown in Figure 1 and 2.

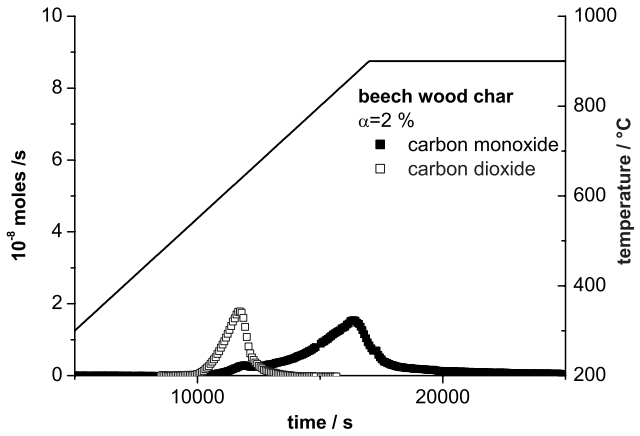

Figure 1. Desorption spectrum for the total active surface area

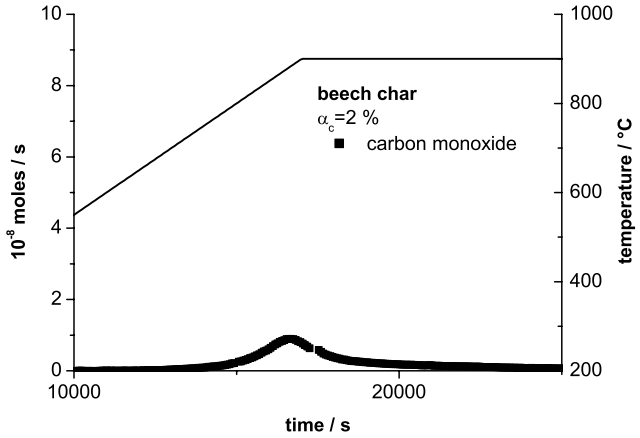

Figure 2. Desorption spectrum for the stable active surface area

The reactive surface areas and reaction rates are determined for different degrees of conversion. The specific surface areas and specific reaction rates for beech wood char and oil palm shell char are shown as a function of conversion degree in figure 3 und 4.

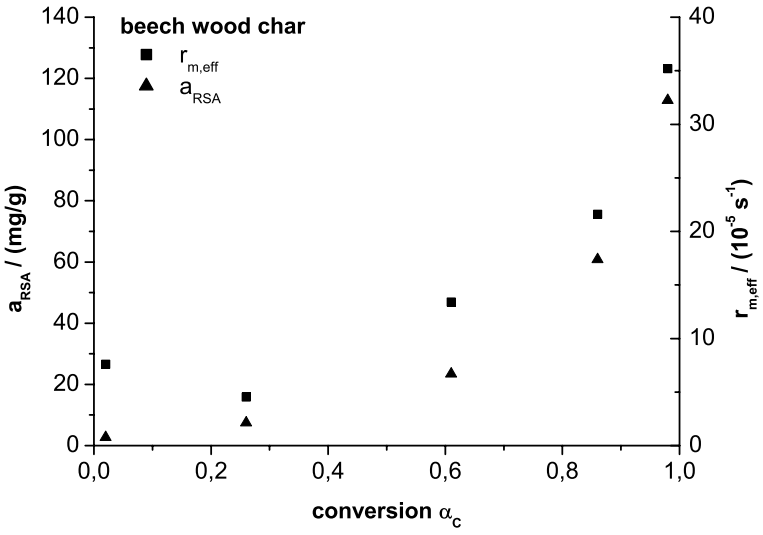

Figure 3. Specific reactive surface area and reaction rate as a function of conversion degree

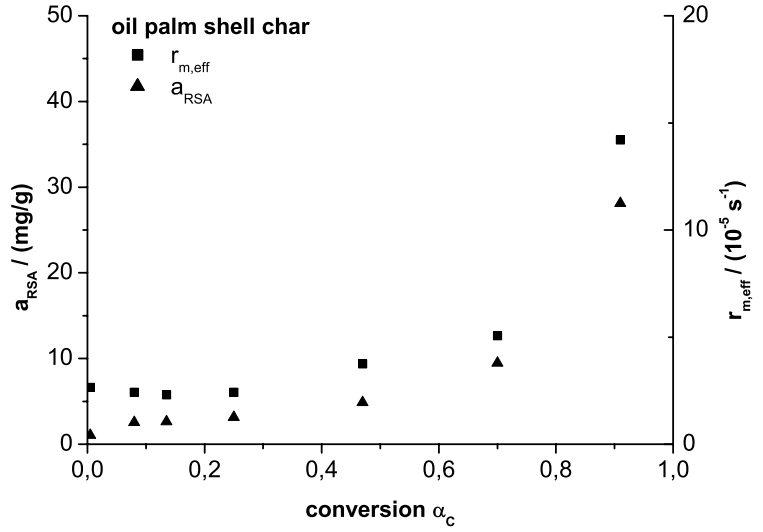

Figure 4. Specific reactive surface area and reaction rate as a function of conversion degree

The specific reactive surface area is related to the specific reaction rate. Figure 5 shows the surface related reaction rate as a function of conversion degree.

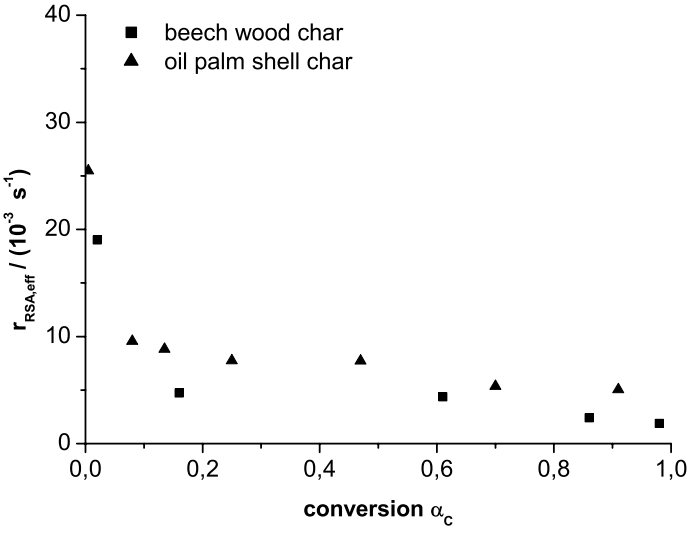

Figure 5: Surface related reaction rate as a function of conversion degree

Figure 7 reveals the specific reaction rate as a function of the specific reactive surface area. From this figure a surface related reaction rate can be determined by linear regression.

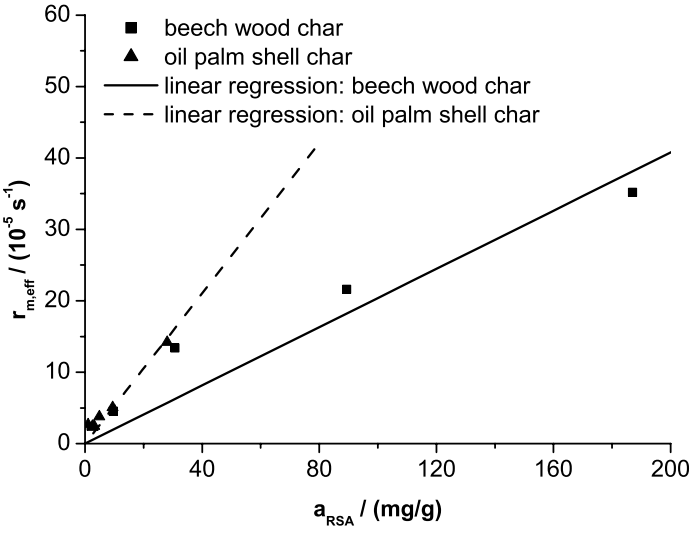

Figure 7: Specific reaction rate as a function of the specific reactive surface area

Conclusions

Temperature programmed desorption represents a suitable technique to investigate the heterogeneity of the surface of biomass chars. The surface complexes of biomass chars can be divided into stable and unstable complexes. Since the specific reactive surface

area is proportional to the specific reaction rate, the reactive complexes can be used to describe the relevant surface during gasification of biomass chars with carbon dioxide. For beech wood char and oil palm shell char, intrinsic surface related reaction rates of $2 \cdot 10^{-3}$ s^{-1} and $14 \cdot 10^{-3}$ s^{-1}, respectively, were determined.

References

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