THERMO-CATALYTIC REFORMING (TCR®) AND TCR®-BIOCHAR PROPERTIES

Markus Heberlein, Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany
Fabian Stenzel, Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany
Andreas Hornung, Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany,
Friedrich-Alexander University Erlangen-Nuremberg, Faculty of Engineering, Department of Chemical and Biological Engineering, Germany,
University of Birmingham, School of Chemical Engineering, UK,
University of Bologna, Italy
markus.heberlein@umsicht.fraunhofer.de

Key Words: Thermo-chemical conversion, Biochar production, Biochar modification, Demineralization

The thermo-catalytic reforming (TCR®) is an endothermic two stage process developed by Fraunhofer UMSICHT, able to process biomass and biomass residues with high ash and moisture contents as well as with low ash melting points. The process is a combination of an intermediate pyrolysis reactor and a reforming stage. The pyrolysis stage is typically running at temperatures between 400 and 500 °C and the reforming stage between 600 and 700 °C. In the first stage pyrolysis vapors and biochar are produced. In the second stage the vapors has to pass a continuous removed biochar bed in the reformer where they (the permanent gas as well as the oil) are upgraded. The temperatures can be varied to modify the products yield, quality and properties in specific ranges. The products are a synthesis gas, biochar and an oil-water fraction which can be separated easily. The products have high quality. The synthesis gas is rich in hydrogen, the oil has a low viscosity and the biochar has very low O:C and H:C ratios - in the same ranges as anthracite - by high C content (mainly depending on the feedstock and the contained ash content) as can be seen in table 1.

Table 1: Ultimate analysis (dry matter basis) of TCR® biochars out of various feedstocks

Sewage sludge biochar		Digestate biochar		Brewers spent grain biochar		Wood biochar	
C	22 %	C	64 %	C	73 %	C	90 %
H	1 %	H	1 %	H	0 %	H	2 %
N	2 %	N	1 %	N	5 %	N	0 %
S	1 %	S	1 %	S	0 %	S	0 %
O*	0 %	O*	1 %	O*	4 %	O*	5 %
Ash	74 %	Ash	32 %	Ash	18 %	Ash	3 %

*Calculation by difference

For biochar from digestate a strong BET-surface increase can be observed for increasing temperature in the reformer stage from 600 up to 700 °C. In contrast the pore size volume is increasing only in a smaller range as a function of temperature. Addition of water into the reformer stage modifies the biochar regarding the pore size distribution. Especially the medium sized and tight coarse pores increase as can be seen in figure 1. Through temperature variation and water injection a biochar modification is possible already during the conversion process. But with increased process temperatures the remaining minerals and therefore the ash content is increased, too. High ash content can reduce possible utilization opportunities. Further treatment like acid leaching for demineralization of TCR®-biochar out of digestate can reduce the ash content from 49 % down to 20 % with a 1 molar hydrochloric acid (pH 0.5) used 1 part biochar in 10 parts acid solution by a biochar particle size of 0.71 - 2 mm.

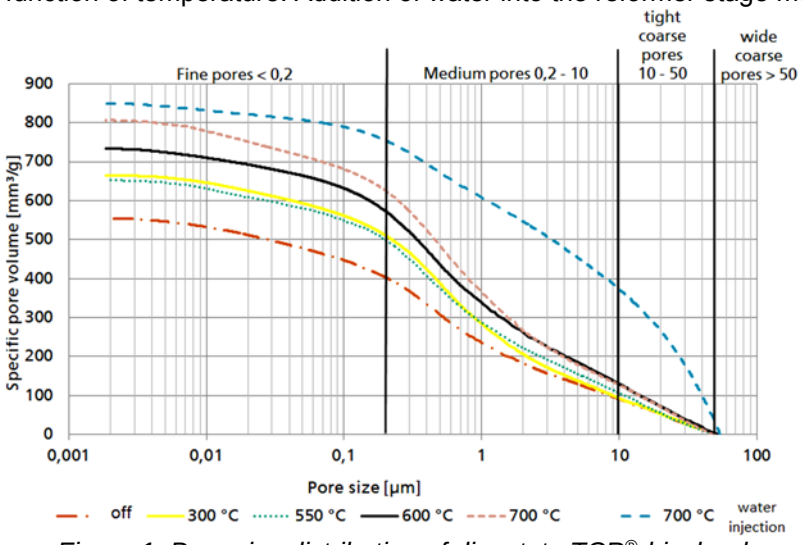

Figure 1: Pore size distribution of digestate TCR®-biochar by various reformer temperatures