

Carbon Benefication in Atmospheric Pressure Microwave Plasma

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Abstract

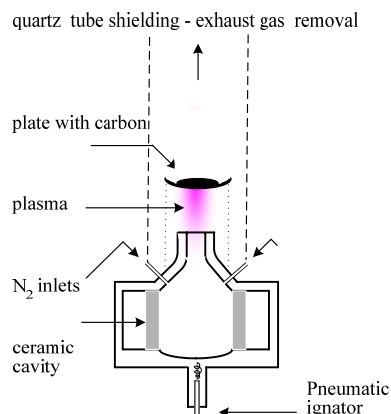
We present the first tests of carbon benefication done by heating of the carbon samples in atmospheric pressure microwave plasma in nitrogen. The diagnostics of carbon samples was performed by SEM equipped with WDX element analyzer and FTIR spectroscopy.

Introduction

Atmospheric pressure microwave (MW) plasmas present considerable interest for a wide range of applications, such as air pollution control, surface treatment, or carbon nanotube growth [1]. Here we present the first tests of benefication of carbon heated in atmospheric pressure microwave nitrogen plasma. The carbon treated is a product of pyrolysis of used tyres. Its benefication is needed to get rid of the volatile components causing its bad smell, and to make it reusable for other processes.

Experimental setup

Atmospheric pressure MW plasma is generated by a Litmas Red plasma torch (2.45 GHz, 3 kW) in N₂. Experimental setup and the basic torch characteristics are described in more detail in [2]. The original carbon sample was placed on a stainless steel plate in the plasma flame about 1cm above the nozzle (Fig. 1). Approximate temperature of the plate was 1500 K. The system was closed and exhausted because of possibly dangerous gases being emitted from polluted carbon samples. The carbon samples were heated for 5 or 10 minutes in nitrogen plasma of 13 l/min flow rate and 1.4 kW generator power. After plasma being switched off, the sample was cooled at a low N₂ flow 2 l/min to avoid oxidation.



The diagnostics of carbon samples was performed directly by a scanning electron microscope (SEM) Tescan TS5136MM equipped with wavelength dispersive X-ray (WDX) INCA Wave analyzer, and on KBr pellets analyzed by Fourier-transform infrared (FTIR) spectrometer Perkin Elmer Spectrum BX.

Results and discussion

After plasma heating of the carbon samples, we first observed that the sample did not smell anymore and its mass decreased (by 27% for 5 min and 48% for 10 min heating). We assume that some volatile substances, most likely aliphatic and aromatic hydrocarbons and their -OH and ether derivatives were released from the carbon, which was confirmed by FTIR spectra (Fig. 2). An apparent reduction of CH₂, C-O-C, -OH, and aromatic C-H functional groups was observed. On the other hand, new compounds were created. We assume

them to be metal oxides of trace elements found by WDX analysis. Detailed interpretation of the measured FTIR spectra requires further investigation. Despite the conductivity of the carbon samples being weak, it was good enough for SEM analysis at low magnifications. Microscopic pictures showed that the carbon has an amorphous structure with pores (Fig. 3). Pictures of the treated samples revealed the steps-like shaped cleaving area (Fig. 5), which compared to the smooth shape in the original sample (Fig. 4) shows that material became more compact.

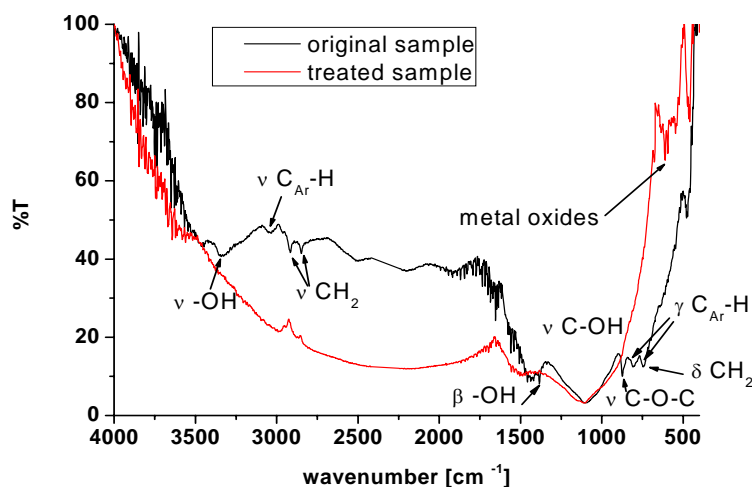


Fig. 2 – FTIR spectra of carbon samples

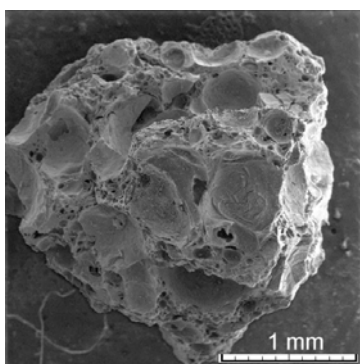


Fig. 3 – Sample shape before the heating

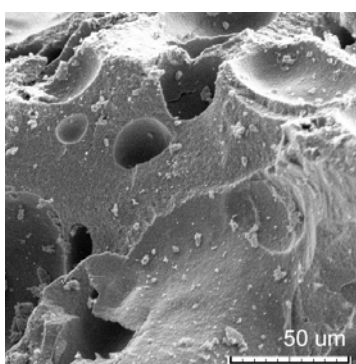


Fig. 4 – Cleaving area and pores before the heating

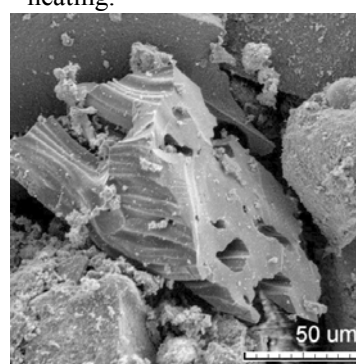


Fig. 5 – Cleaving area and pores after the heating

Summary and perspectives

Atmospheric pressure nitrogen microwave plasma was used as a heat source for used tyre carbon beneficiation. The plasma heat treatment causes a mass loss, a composition change and a structure change of the carbon. We are currently adapting the microwave torch system so that the carbon powder could be inserted directly into the plasma chamber, which will provide a higher temperature compared to when the sample is heated on the supporting metal plate. The new setup will turn the plasma chamber upside down to enable the collection of the treated carbon powder. Because of the presence of pores we also plan further investigations of the treated carbon, such as measuring its adsorption capacity. This could be interesting for its potential use as an active carbon.

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References

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