PRODUCTION OF CARBON BLACK AND HYDROGEN FROM PLASMA TORCH WITH NATURAL GAS

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Introduction

The refine of petroleum usually needs a large quantity of hydrogen. The environmental restrictions lead the search for new ways to produce hydrogen without CO_2 emission. Several groups are studying the hydrogen production from methane by plasma processes [1-5]. We studied the production of carbon black and hydrogen from plasma torch of natural gas and nitrogen. The products are obtained without CO_2 emission which usually happens when other techniques such as steam reform are employed.

Experimental

Two types of plasma torch (with hot cathode and non-transferred arch) were used: the first with one vortex chamber (Fig. 1a) and the second with two chambers (Fig. 1b). The plasma jet is produced by an electric arch confined inside an anode made of a copper tube cooled by water. The plasma confinement is made by gas in vortex and thermal pinch.

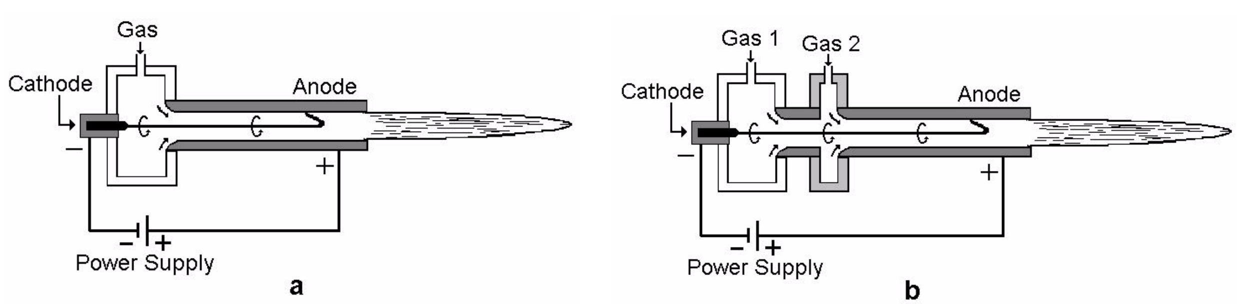

Fig. 1. Plasma torch: a) with one vortex chamber ; b) with two vortex chambers.

In the first case (Fig. 1a), initially a nitrogen plasma with 40 kW was produced. A flow of nitrogen (110 Nl/min) was injected in the vortex chamber. Then, a flow of natural gas (59 Nl/min) was injected inside the plasma jet at the exit of the anode channel during 13 min.

In the second case (Fig. 1b), a flow of nitrogen with 76 Nl/min and 27 Nl/min was injected in the first and in the second vortex chamber respectively. After that, at the second chamber, the nitrogen was reduced to 15 Nl/min and natural gas (23 Nl/min) was introduced. This condition was maintained during 8 min with 33 kW.

For cooling the plasma and to obtain carbon black we have used a reactor at the anode exit. This reactor (shown in Fig. 2) was made using a copper tube with 66 mm of internal diameter and 2 m of length, cooled with water. A dust filter filled with PTFE was installed in the exit of the reactor.

The gaseous products were characterized by using a mass spectrometer (OmniStar BK M26 253) connected with the reactor exit. The produced carbon black was characterized by BET surface area and Scanning Electron Microscopy.

Fig. 2. The plasma torch at left, connected at a tubular reactor.

Results and Discussion

The gaseous products observed by mass spectroscopy are shown in Fig. 3. The measurements do not indicate significant differences in the gaseous compositions obtained with the systems of Fig 1a and 1b. It can be observed that the natural gas was well dissociated with the production of H_2 and C_2H_2 (and/or HCN). The used equipment cannot distinguish between C_2H_2 and HCN. To eliminate this doubt in future, it will be used a CG-MS.

The BET surface area of the produced carbon black was 137 m^2/g for the first case (Fig. 1a) and 173 m^2/g for the second (Fig. 1b). The carbon black produced with the system of Fig. 1b has a larger amount of smaller particles. The operational conditions with this system of the double vortex chamber were more difficult to stabilize because the interaction between the natural gas and the electric arc can change the plasma VxI characteristic curve. On the other hand, when the natural gas is injected outside of anode, we can vary the flow rate without interfering in the plasma VxI characteristic curve.

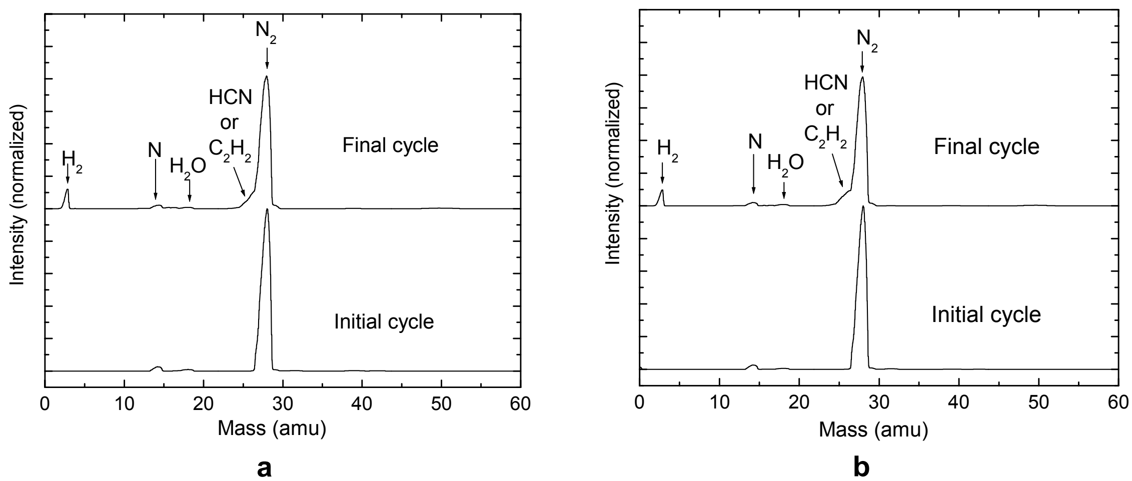

Figure 3. Mass spectroscopy measurements for the two used systems.

Conclusions

Hydrogen and carbon black were produced with a nitrogen plasma torch. The nitrogen use may produce undesirable compounds such as HCN. The experiments showed that it is easier the operational control with the injection of natural gas at the exit of the anode channel.

Acknowledgements

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