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STUDY OF THE CATALYTIC PYROLYSIS OF CARBOHYDRATES THROUGH THERMOGRAVIMETRY

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ABSTRACT

The influence of various acidic, basic and neutral catalysts on the pyrolysis of pure carbohydrates present in agricultural products was studied. Thermogravimetry was coupled with gas chromatography and mass spectrometry to identify the products. Information was also obtained concerning the rate these compounds form as a function of time and temperature. This allows the improvement of the present hypotheses of carbohydrate pyrolysis.

INTRODUCTION

The pyrolysis of various carbohydrates, mainly cellulose, has been the subject of various studies including the use of thermogravimetry. Many of the efforts, however, were made to prevent the pyrolysis of cellulose and its decomposition products so that an effective flameproofing method for cotton, an almost pure cellulose, could be developed. Considering the amount of solid residues after pyrolysis, the decomposition of a carbohydrate may be bracketed between two limiting reactions:

$$C_6H_{12}O_6 \longrightarrow 6\,C + 6\,H_2O \quad \ldots\ldots 1 \quad (40\%)$$

$$C_6H_{12}O_6 \longrightarrow 6\,CO + 6\,H_2 \quad \ldots\ldots 2 \quad (0\%)$$

In actuality, the reaction product is a mixture of water and various combustible gases. Flame retardants tend to promote the formation of more water. Since our goal is the conversion of carbohydrates to useful chemicals we are undertaking a sytematic study on the effect of various additives which can shift the reaction away from excessive water formation.

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RESULTS AND DISCUSSION

The pyrolysis of carbohydrates (glucose, maltose, cellobiose, amylose and cellulose) resulted in the formation of 2.6-2.8 moles of water per hexose unit in the absence of any additive. This water formation is less than that described in equation 1. Two distinctive ranges of decomposition were observed with the first three compounds, but only one with amylose and cellulose. The volatile products in the first range were composed almost exclusively of water. The volatile fraction in the second range did not have a dominant major component, as determined through GC-MS technique, but had a large number of organic compounds in small quantities. DSC and DTA studies indicated mildly endotherm processes.

The use of various inorganic catalysts had pronounced effects on the pyrolytic processes. Acidic additives shifted the ranges toward lower temperature, generally retaining the two ranges where applicable. Basic catalysts induced the pyrolysis at somewhat even lower starting temperature, but the ranges were less distinct. At the same time, the amount of water decreased to 2.0-2.1 moles with acidic catalysts and to 1.5-1.6 moles with the basic ones. The volatile products also decreased, but interestingly more with acidic than basic catalyst. The composition of the pyrolytic products will be discussed in relation to the types of additives used. DTA studies suggests that some of the additives change the endotherm reactions to exotherm processes.