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High Temperature Reactions in Microstructured Reactors – Synthesis of Biphenyl by Dehydrocondensation of Benzene

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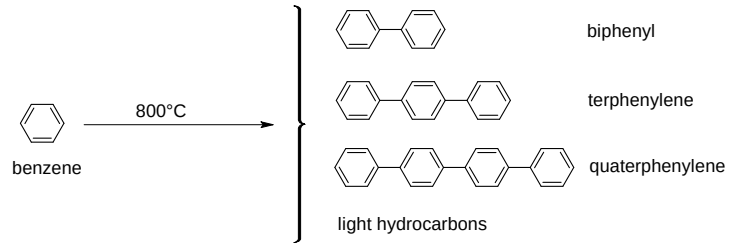
Introduction

The aim of the previous investigations was to show the feasibility of microstructured reactor processing for the dehydrocondensation of benzene to biphenyl. Such kind of reactions are mostly of radical nature and very fast but with low selectivity. A formation of biphenyl by establishing a C-C bond is not preferred for this reaction mechanism, and therefore, as the main products low molecular hydrocarbons and coke are expected. Nevertheless the industrial production of biphenyl is done in this way.

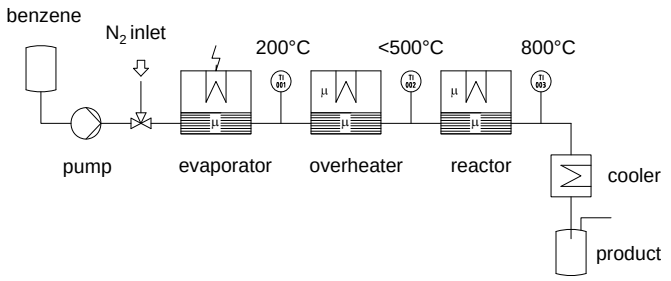
To increase the yield of biphenyl the residence time should be extremely short to avoid the possible coke formation. To reach this achievement fast heating and quenching of the reaction mixture by cooling is advantageous. To fulfill these preconditions microstructured reactors seem to be the best choice due to their high surface-to-volume ratio. It was assumed that the decomposition of benzene into side products can be diminished by quenching of radicals at the walls of the microchannels. Also heat is easily transferred into the microchannels and the small hydraulic diameter of the single channels allow very high flow rates and low residence times below one second.

Experimental setup

General formula scheme

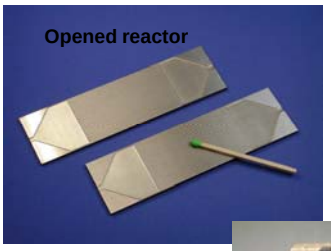


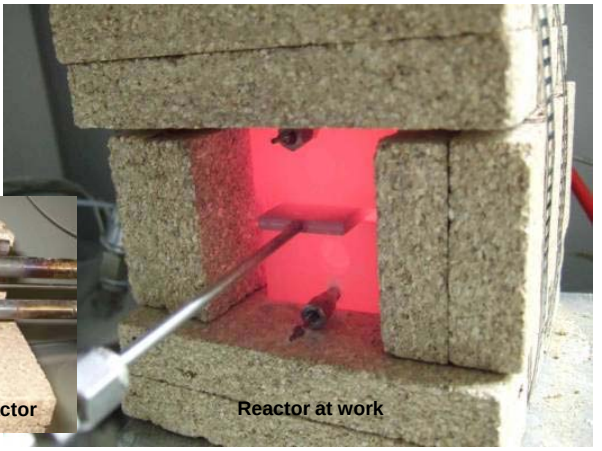
Flowchart



Reaction conditions

Flowrate:	0.1 ml/min
Time on stream	10 min per run
Temperatures	
evaporator:	200°C
overheater	250°C
reactor	800°C
cooler	<60°C

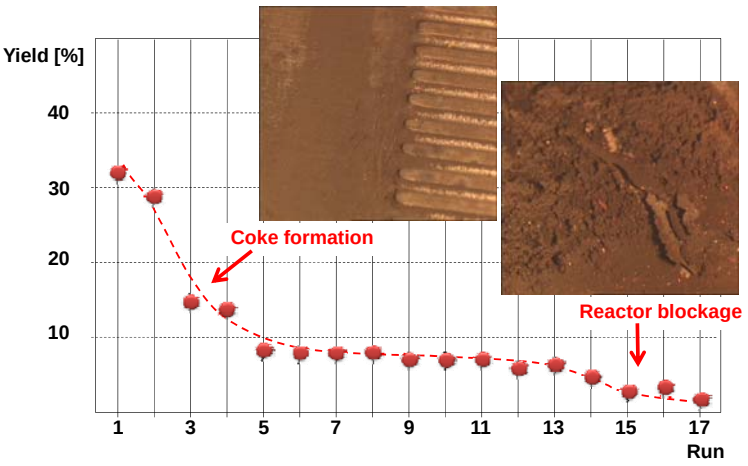




Reactor internals

Material:	stainless steel (1.4571)
Number of plates	2
Number of channels:	28
Channel length:	50 mm
Channel height	800 µm
Channel width:	600 µm
Reactor volume total:	0.8 cm^3

Results



The used of microstructured devices in the laboratory set-up should ensure an extremely fast heating of benzene from room temperature up to 850°C within milliseconds. High yields of 30% of biphenyl, compared to the respective data given in literature (approx. 1-7%), could be achieved. Under pyrolysis conditions a heavy coke formation takes place even at short residence times below 500 ms, and the initial high yield decreases rapidly with the increase of time on stream of the reactor. Consequently, the high-temperature pyrolysis of benzene to biphenyl is a good example to show possible drawbacks of a microstructured reactor and to make clear that chemical micro processing is a useful but not almighty tool.

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