Table 5. Results of high-temperature hydrogenation of the hydropurified mixture

Characteristic	Value
Yield of liquid products, wt %	95.7
Yield of gases (C_1–C_4, CO + CO_2), wt %	3.8
Hydrogen consumption in reaction, wt %	1.2
Coke content on catalyst, wt %	3.2
Yield of pure products in sharp rectification, wt %:	
benzene	51.3
naphthalene	23.6

The initial mixture contains 15.8% tetralin, 47.6% benzene, and 10.2% naphthalene. Hydrogenation conditions: laboratory system; 4.0 MPa, 500°C; flow rate 1.0–1.2 kg/L h; 12–15% steam; catalyst 5% MoO_3 + HNaY zeolite.

ular, naphthalene), which are separated out from the products and sold commercially.

It follows from Table 5 that the water vapor (steam) ensures a high yield of the liquid products (95.7%), with little gas formation (3.8%) and little hydrogen consumption (1.2%). In high-temperature hydrogenation, the tetralin remains largely intact. However, we note increase in the yield of benzene (from 47.6 to 51.3% in the products) and naphthalene (from 10.2 to 23.6%). The presence of carbon oxides in the gas indicates indirectly that the coke deposits on the catalyst in high-temperature hydrogenation may react with steam, forming such oxides.

The experiments show that steam plays a positive role in slowing the formation of high-molecular compounds, which are sources of coke deposits on the catalyst (Fig. 3).

We see in Fig. 3 that, in the presence of steam, coke deposition on the catalyst is decreased by 20–25%: from 0.20–0.33% without steam to 0.09–0.12% with 15% steam. Consequently, the catalyst retains its activity over a long period without the need for regeneration. According to promotional material published abroad, the introduction of steam permits the operation of hydrodealkylation catalysts for more than a year without regeneration.

In Fig. 4, we show the influence of steam on naphthalene formation. We see that the yield of naphthalene at the optimal hydrogenation temperature (560°C) is 64.2% in the absence of steam but only 55.5% in the presence of steam. This may evidently be explained in that more benzene and toluene is formed in the presence of steam, but we obtain smaller quantities of the alkylnaphthalenes primarily converted to naphthalene.

On the basis of our observations, the action of steam in the catalytic high-temperature hydrogenation (hydrodealkylation) of a purified mixture of the 180–230°C naphthalene fraction mixture of semicoking tar from Shubarkol coal and raw coke-plant benzene may be described as follows. The steam, on the one hand, blocks the smallest pores in the catalyst, from which the removal of products is difficult, and, on the other, facilitates their desorption from the large pores, thereby decreasing the likelihood of polymerization of the reactive products of intermediate hydraulic cracking and hydrodealkylation and hence slowing coke deposition on the catalyst. Another possibility is oxidative reaction between water and methylene radicals on the surface of catalysts containing oxides of type Al_2O_3.

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