

**ACHIEVING HIGH SELECTIVITY AND PRODUCTIVITY IN THE
PROCESS OF HYDROCARBON SYNTHESIS BY SEQUENTIALLY
INTRODUCING CATALYST COMPONENTS.**

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The results of the study show that the introduction of active metals and modifiers in the appropriate sequence in the preparation of a catalyst with a composition of 20% Co–20% Fe–5% B–1.5%Zr*Na made it possible to create a material with high catalytic activity, selectivity, and productivity, selected for the process.

With the catalyst prepared in this way, the CO conversion was 82%, and the yield of liquid C₅⁺ fractional products increased to 138 g/m³. This confirms that the composition and surface structure of the active centers are optimized for the reaction, and a synergistic effect occurs in the interaction of the active metal and modifiers.

According to the selectivity analysis, the formation of C₁–C₄ gaseous hydrocarbons decreased by up to 14%, which indicates that the catalyst surface was reshaped in a direction that reduced the formation of low molecular weight products. At the same time, the selectivity for C₅⁺ products increased to 81%, indicating that the reaction was directed towards the target products.

The hydrocarbon chain growth coefficient (α), which evaluates the fractional activity of the catalyst, also increased from 0.84 to 0.87 in proportion to the productivity of liquid hydrocarbons. This indicator reflects the efficiency of chain extension reactions. In particular:

At $\alpha = 0.84$ – 0.85 , the fractional composition of gasoline (C₅–C₁₀) fraction was 47–50%, diesel (C₁₁–C₁₈) fraction was 39–40%, and C₁₉⁺ fraction was 11–13%. At $\alpha = 0.87$, gasoline and diesel fractions were formed in almost equal amounts (42%), and the C₁₉⁺ high molecular weight fraction increased to 16%.

Analysis of the group and structural composition of the products showed that the highest proportion of unsaturated ethylene hydrocarbons (mainly C₂H₄) — 6% — was recorded in the presence of the 20% Co–20% Fe–5% B–1.5% Zr*Na catalyst. This indicates that the catalyst also has partial activation centers for dehydrogenation reactions.

Also, the proportion of paraffins in the output products is 75%, which means that it provides high energy yield as a fuel through the dominance of chain length and saturated structures. Such structures are especially valuable as diesel and aviation fuels.

Based on the data in Table 2, the catalytic properties of the 20% Co–20% Fe–5% B–1.5% Zr catalysts used in the synthesis of hydrocarbons were evaluated in terms of their differences in the effects of different promoters - sodium chloride (NaCl) and sodium hydroxide (NaOH). All experiments were carried out at optimal temperature conditions (T_{maq}), and the activity, selectivity, and product yield of the catalysts in the formation of hydrocarbons from CO and H₂ gases were analyzed.

The results of the catalyst with NaCl addition show that it exhibited the lowest catalytic activity in the series. Despite the optimal temperature:

CO conversion was 89%, but the yield of liquid C₅⁺ fractions was low, only 60 g/m³.

Table 1

Results of hydrocarbon synthesis from CO and H₂ in the presence of 20% Co–20% Fe–5% B–1.5% Zr (0–2) % Na/Al₂O₃ catalysts at the optimum temperature (T_{maq})

Sodium compound	T_{maq}	X_{CO} , %	Unum, g/m ³		Selective sensitivity, %				α
			C ₂ –C ₄	C ₅ ⁺	C ₂ –C ₄	C ₅ ⁺	C ₅ –C ₁₀	C ₁₁ –C ₁₈	
NaNO ₃	190	72	15	112	12	9	45	41	0,86
NaCl	210	82	10	138	8	6	42	42	0,87
Na ₂ CO ₃	210	86	17	140	9	9	52	38	0,83
NaOH	220	87	14	47	6	7	54	37	0,82

At the same time, the yield of C₁–C₄ gaseous fractions reached 28 g/m³, which led to a decrease in selectivity to the target liquid products. The selectivity for the methane formation reaction was also 11%, which indicates the activity of excessive methanation processes.

NaCl, as an ionic chlorine component, can negatively affect the active sites on the catalyst surface, partially passivating them, and slowing down the radical steps in the reaction mechanisms. This is manifested by a decrease in the yield of liquid products.

On the other hand, when 20%Co–20%Fe–5%B–1.5%Zr*Na catalysts were prepared based on NaOH, i.e., when sodium hydroxide was used:

CO conversion was observed to increase to 68%.

This is explained by the strengthening of the basic environment on the catalyst surface, the correct formation of active centers in the structure, and the activation of adsorption-activation processes of gas components.

In the presence of NaOH, Na⁺ ions, introduced as a modifier, regulate the interaction between the carrier surface and metal centers. This allows increasing the productivity of liquid fractions and limiting the formation of gaseous (methane, C₂–C₄) fractions.

The experimental results presented in the table show the effect of the addition of various amounts (0–2%) of sodium promoter to catalysts with a composition of 20% Co–20% Fe–5% B–1.5% Zr on the main technological parameters of the synthesis process carried out on the surface of the Al₂O₃-based support. All experiments were carried out at optimal temperature conditions (T_{maq}), and parameters such as CO conversion, liquid and gaseous product yields, and selectivity of the catalysts were evaluated.

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