The Pd-Fe/SiO$_2$ samples (S$_{specific}$ = 291 m^2/g) obtained by co-impregnation with H$_2$PdCl$_4$ and Fe(NO$_3$)$_3$ solutions were studied using the Thermally Programmed Reduction-H$_2$ (TPR-H$_2$) method (Fig.-5).[44]
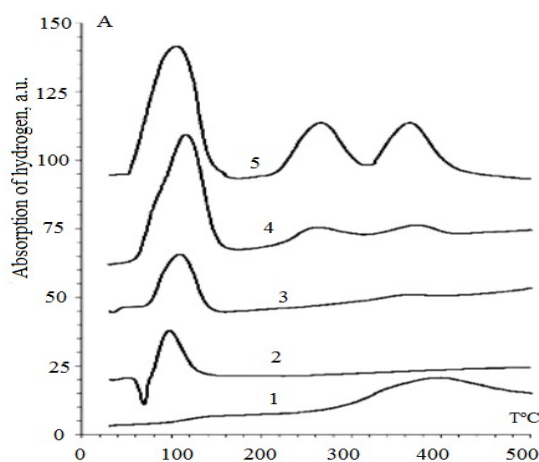

Fig.-5:TPR-H$_2$ Curves of Samples calcined at 500°C: (1) 8Fe / SiO$_2$, (2) 5% Pd / SiO$_2$, (3) 5% Pd-1% Fe / SiO$_2$, (4) 5% Pd-8% Fe / SiO$_2$, (5) 5% Pd-20% Fe / SiO$_2$[44]

It was shown that the reduction of a monometallic 5Pd/SiO$_2$ sample occurs in two stages in the temperature range of 50-150 °C. The peak at 50–70 °C corresponds to the desorption of hydrogen from β-PdH obtained by the reduction of palladium oxide weakly bound to the carrier. At 90 - 150°C, PdO is reduced to Pd^0. The 8Fe/SiO$_2$ monometallic iron sample is reduced in a wide temperature range of 300–500 °C. The reduction of bimetallic samples starts at 100°C and ends at 300°C, but there is a shift in the PdO reduction profile to a region of elevated temperatures, probably associated with the reduction of Pd$_x$Fe$_y$O particles. For bimetallic samples, there is no peak characteristic of β-PdH.

Bimetallic Fe-Cu/SiO$_2$ systems were proposed for the process of liquid-phase hydrogenation of p-dinitrobenzene to p-phenylenediamine.[50,51]The most active catalysts were synthesized by co-precipitation of metal precursors by urea hydrolysis. The strong interaction of Fe and Cu nanoparticles in catalysts associated with the preparation method facilitated the hydrogenation of p-dinitrobenzene in the liquid phase with a selectivity higher than 80 % for p-phenylenediamine.

The strong interaction of Fe and Cu nanoparticles in the catalysts, due to the synthesis method, promotes the process of effective hydrogenation of p-dinitrobenzene in the liquid phase. The highest selectivity (89%) for p-phenylenediamine and 100% conversion of p-dinitrobenzene at T = 145–180° C, P$_{H2}$=1.3 MPa was achieved on catalysts containing 7% iron and 3% copper, which were obtained by co-precipitation with further calcination at 300°C.[51]

CONCLUSION

The researches of hydrogenation reactions of aromatic nitro compounds to the corresponding amines on nickel and iron catalysts are described. The advantages of skeletal catalysts are determined by the metal base and are in their mechanical strength, improved heat transfer, relatively low cost. The main technological disadvantages in the use of skeletal catalysts are reduced to the necessity of processing synthesis waste, possible deactivation of the catalyst both during its operation and during reactor loading, and its pyrophoricity. In recent years, the attention of researchers has increasingly been attracted to the study of the reduction of organic compounds with various functional groups in the presence of iron-containing catalyst systems to decrease the cost of catalysts and less use of expensive noble metal catalysts. The combination of two types of metals in catalysts can lead to the formation of solid solutions of Fe-Me (Me - Ni, Pd, Pt, Ru) and, as a result, to a change in the catalytic properties of monometallic iron-containing catalysts.

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