COPPER(II)-SILICA COMPOSITES AS HETEROGENEOUS CATALYSTS FOR SYNTHESIS OF CONDENSED PYRIDINES FROM PROPARGYLAMINE AND CYCLIC KETONES

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Pyridines condensed with cycloalkanes are good precursors to piperidines and suitable building blocks for medicinal chemistry due to their high fraction of sp^3 carbon atoms (Fsp3) and the hydrophilic pyridine ring. For decades, different methods of synthesis of this class of compounds have suffered from low yields and few suitable substrates. In our previous work we modified the known Abbiati method [1], via replacing the expensive aurum salt by copper salts, achieving higher preparative yields and lab-friendly conditions [2]. Our next goal was to adopt the reaction to flow reactor conditions obtaining scale up for the process and elaborating easier purification procedures.

Flow reactors require a design of a catalyst suitable for arranging them in a cartridge. Such approach is studied well for hydrogenation reactions catalyzed by palladium catalysts, but also tested on Co-based catalysts [3]. Approach used to prepare cobalt-containing catalysts was used to synthesize copper composites. A complex of copper(II) with a nitrogen-containing ligand sorbed on silica was pyrolysed (Fig. 1). PXRD, SEM and TEM confirmed forming a composite of copper nanoparticles with carbon on silica. The catalyst samples were tested using the flow reactor with the model substrates studied in our previous study (Fig. 2) [2].

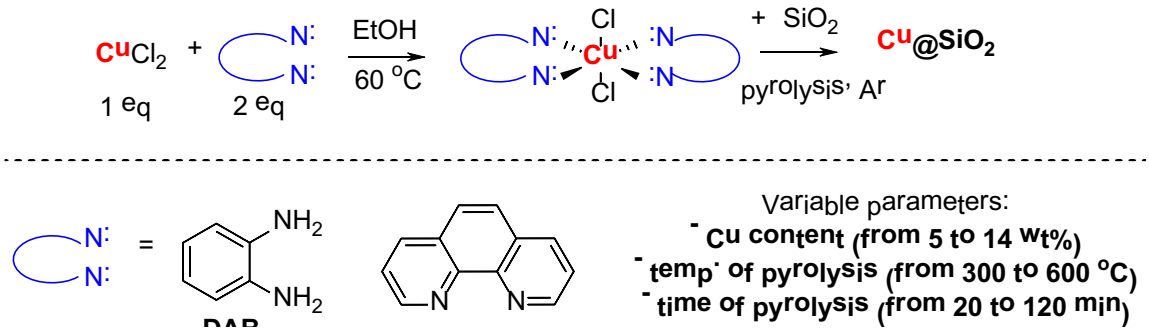

Fig. 1. Scheme of catalyst preparing

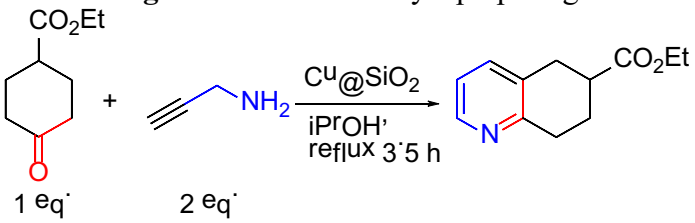

Fig. 2. Scheme of model reaction

The data on the catalytic activity are collected in Table 1. Complexes with DAB seem to provide more effective catalysts. Increasing copper content from 5 to 14wt% did not affect the yield of the condensation product, while pyrolysis at 600 °C decreased the catalytic activity. Despite the generally smaller yields achieved by using heterogeneous $Cu@SiO_2$ catalyst compared to those with soluble Cu salts, the advantage of using the flow-reactor technology is undeniable.

Table 1. Study of catalytic activity of different catalyst samples

Complexes on silica	Cu content, %	Temperature of pyrolisis	Time of pyrolysis, min	Yields after 3.5 hours of the reaction, %
$Cu(DAB)_2Cl_2$	14	300	30	46
$Cu(DAB)_2Cl_2$	**5**	**400**	**20**	**62**
$Cu(DAB)_2Cl_2$	5	400	20	58
$Cu(DAB)_2Cl_2$	6	400	20	48
$Cu(DAB)_2Cl_2$	14	400	40	42
$Cu(DAB)_2Cl_2$	7	600	20	38
$Cu(Phen)_2Cl_2$	4	300	30	56
$Cu(Phen)_2Cl_2$	14	300	30	51
$Cu(Phen)_2Cl_2$	14	400	100	48
$Cu(Phen)_2Cl_2$	14	400	20	45
$Cu(Phen)_2Cl_2$	7	400	100	41
$Cu(Phen)_2Cl_2$	4	400	20	40

$Cu(Phen)_2Cl_2$	7	400	20	35
$Cu(Phen)_2Cl_2$	14	400	40	33
$Cu(Phen)_2Cl_2$	14	400	100	29
$Cu(Phen)_2Cl_2$	7	400	100	27
$Cu(Phen)_2Cl_2$	7	600	120	35
$Cu(Phen)_2Cl_2$	7	600	120	31
$Cu(Phen)_2Cl_2$	14	600	120	28

1. Abbiati G., Arcadi A., Bianchi G., Giuseppe S. Di, Marinelli F., Rossi E. Sequential amination/annulation/aromatization reaction of carbonyl compounds and propargylamine: A new one-pot approach to functionalized pyridines. *Journal of Organic Chemistry*. 2003. Вип. 68, № 18. С. 6959–6966.
2. Sotnik S. O., Subota A. I., Kliuchynskyi A. Y., Yehorov D. V., Lytvynenko A. S., Rozhenko A. B., Kolotilov S. V., Ryabukhin S. V., Volochnyuk D. M. Cu-Catalyzed Pyridine Synthesis via Oxidative Annulation of Cyclic Ketones with Propargylamine. *The Journal of Organic Chemistry*. 2021. С. acs.joc.0c03038.
3. Asaula V. M., Buryanov V. V., Solod B. Y., Tryus D. M., Pariiska O. O., Kotenko I. E., Volovenko Y. M., Volochnyuk D. M., Ryabukhin S. V., Kolotilov S. V. Catalytic Hydrogenation of Substituted Quinolines on Co–Graphene Composites. *European Journal of Organic Chemistry*. 2021. Вип. 2021, № 47. С. 6616–6625.