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Investigation of the Photocatalytic Activity of Nickel Ferrite-Iron Oxide Materials

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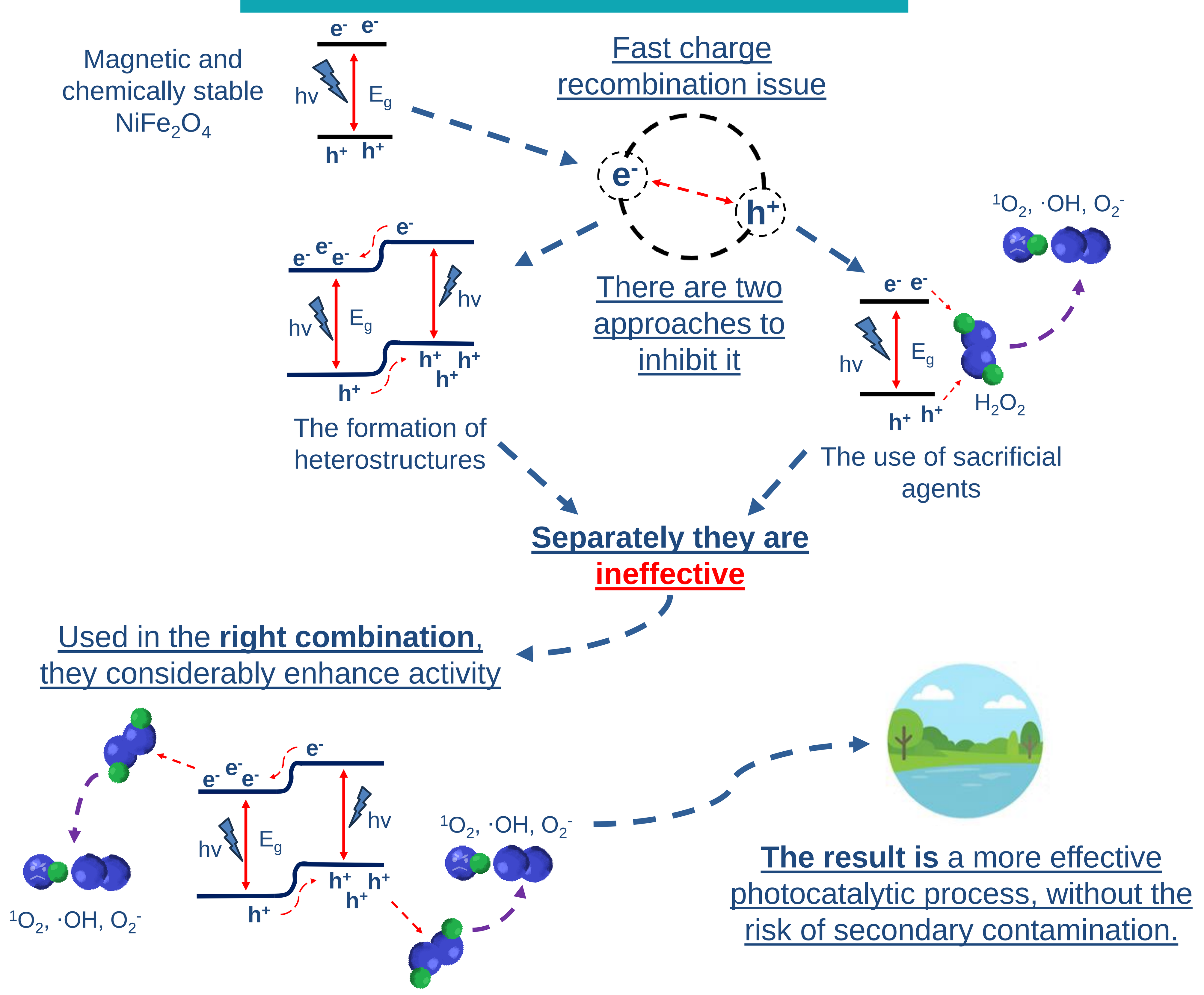
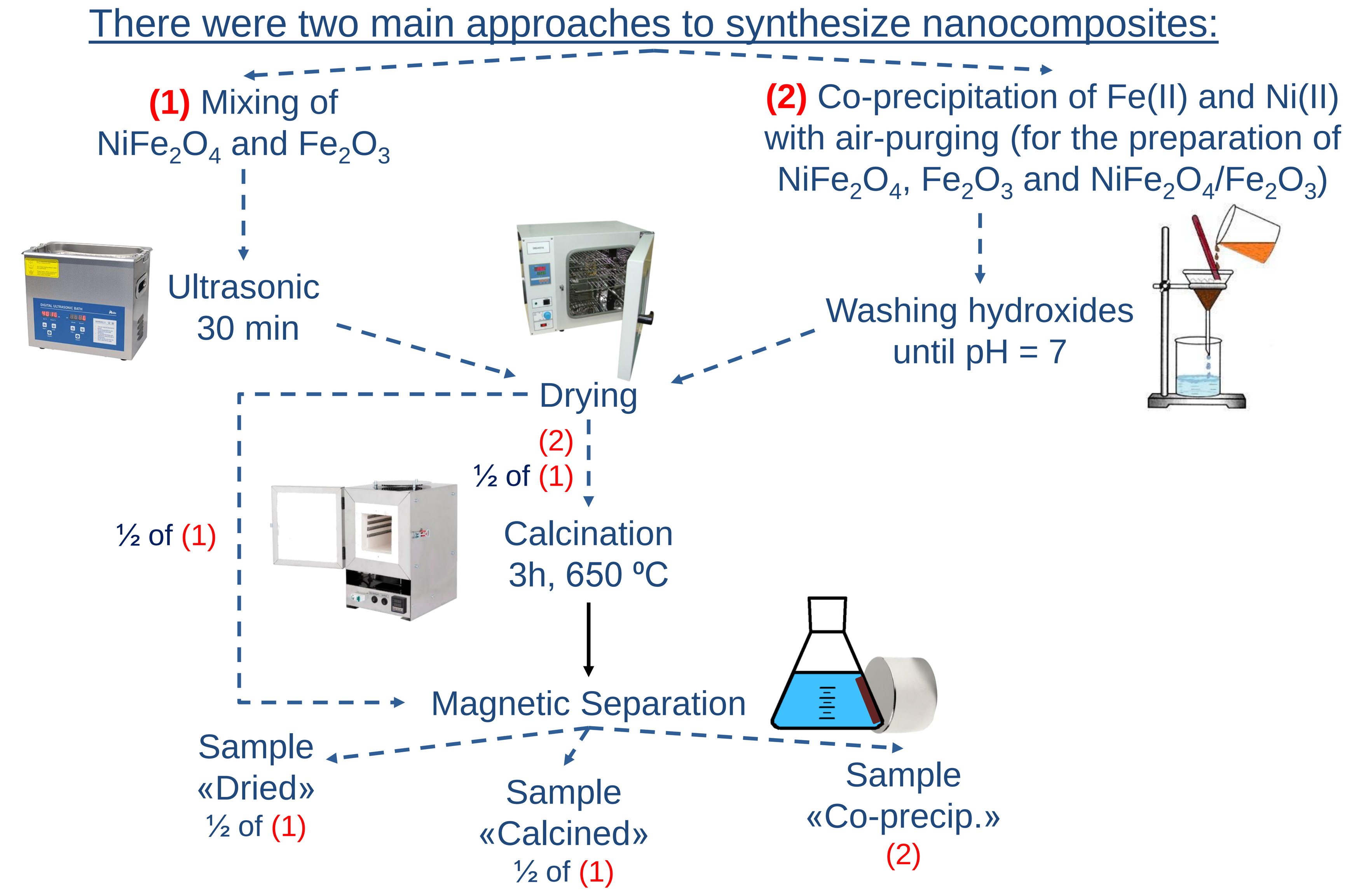
INTRODUCTION & AIM

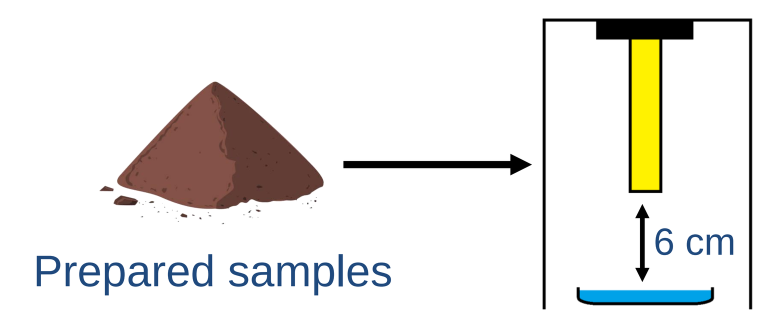


The aim of the study is to synthesize $NiFe_2O_4/Fe_2O_3$ materials and examine their photocatalytic activity for indigo carmine (IC) degradation in the presence of sodium citrate, hydrocarbonate and H_2O_2.

Preparation technique



Photocatalytic activity technique



Indigo carmine ($40\ \mu M{\cdot}L^{-1}$, 20 mL)
Light source: UVA lamp (λ_{max} = 340 nm, 26 W)
t_{dark} = 15 min
t_{light} = 45 min

Sacrificial agents:
$NaHCO_3$ 22 mmol*L^{-1}; Na_3Cit 95 mmol*L^{-1}; H_2O_2 10 mmol*L^{-1}
Added separately or simultaneously

Characterization

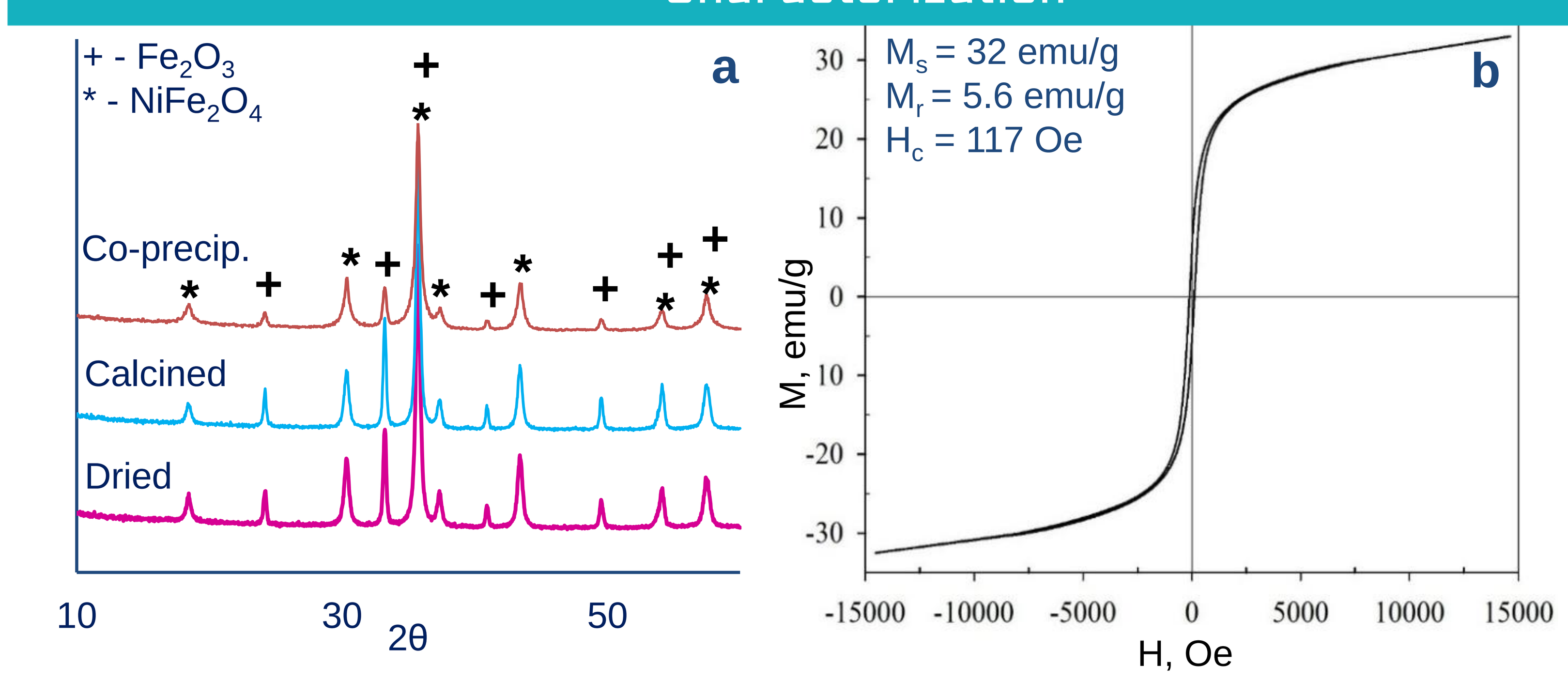


Fig. 1 (a) XRD data and (b) magnetic properties of the prepared samples

Sample	Compositions, %		Stability during magnetic separation	The use for the further study
	Fe_2O_3	$NiFe_2O_4$		
Dried	78.9	21.1	Significant losses of Fe_2O_3	-
Calcined	82.3	17.7	Losses of Fe_2O_3	-
Co-precip.	90.4	9.6	Stable	Characterization and photocatalysis

The magnetic properties of the co-precipitated sample indicate that it behaves as a magnetically soft ferrimagnet (Fig. 1b). The observed coercivity (Hc) at the nanoscale (Fig. 2a) is attributed to the presence of relatively large particles (~20 nm, Fig. 2b) and their tendency to agglomerate.

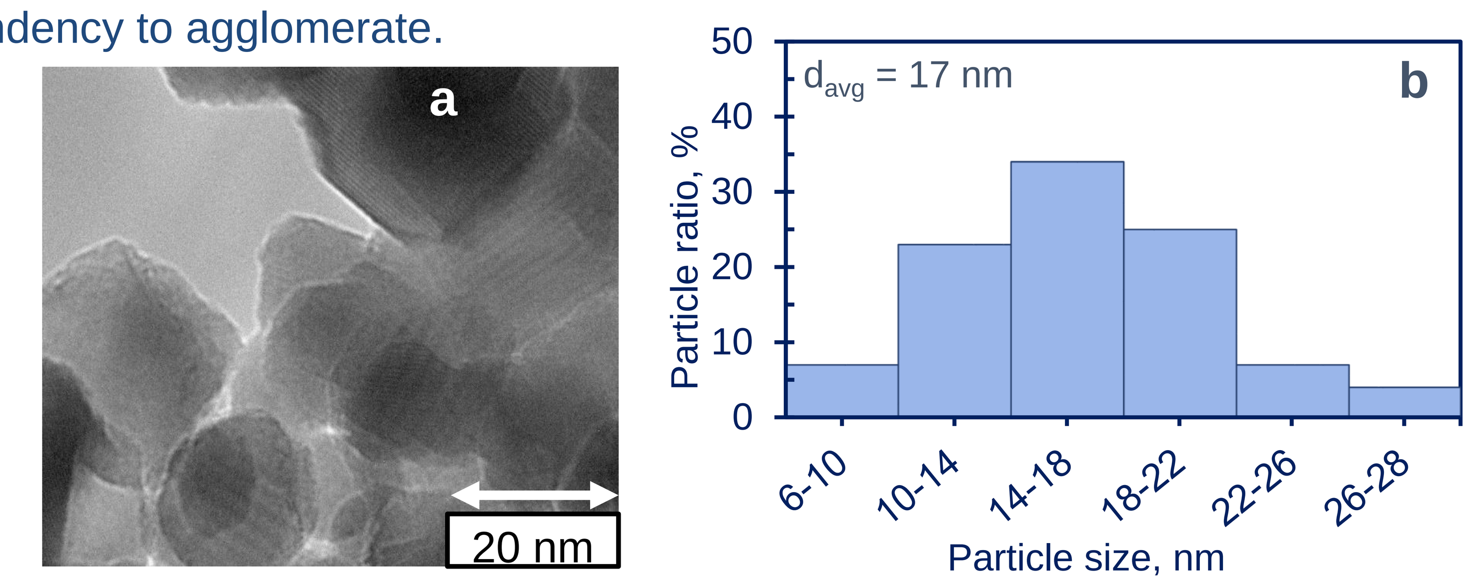


Fig. 2 (a) TEM image and (b) particles' size distribution in the «co-precip.» sample

Photocatalytic activity study

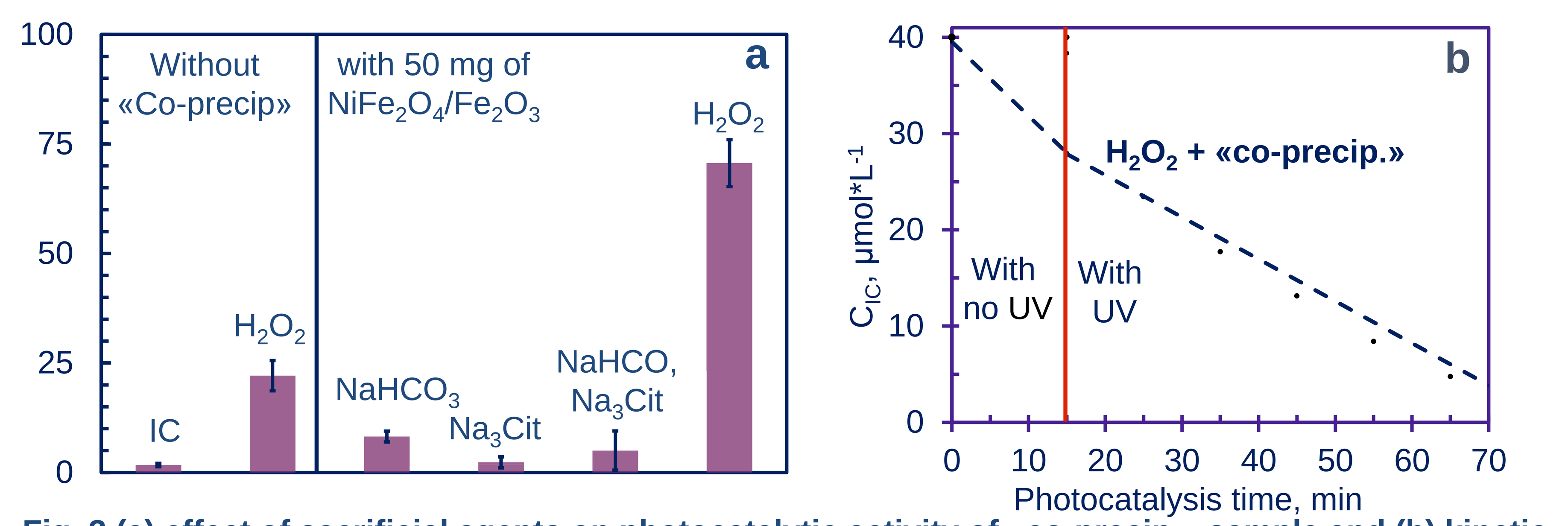


Fig. 3 (a) effect of sacrificial agents on photocatalytic activity of «co-precip.» sample and (b) kinetic curves of IC degradation

Fastest degradation of IC occurred with H_2O_2: 70% dye degradation in 60 min (Fig. 3a). Reaction order: pseudo-zero; k_{app} = 0.432 µmol L^{-1} (Fig. 3b).

A strong dependence on mass is observed in the range of 10–50 mg (Fig. 4). A further increase in mass does not lead to a proportional increase in the activity of the sample.

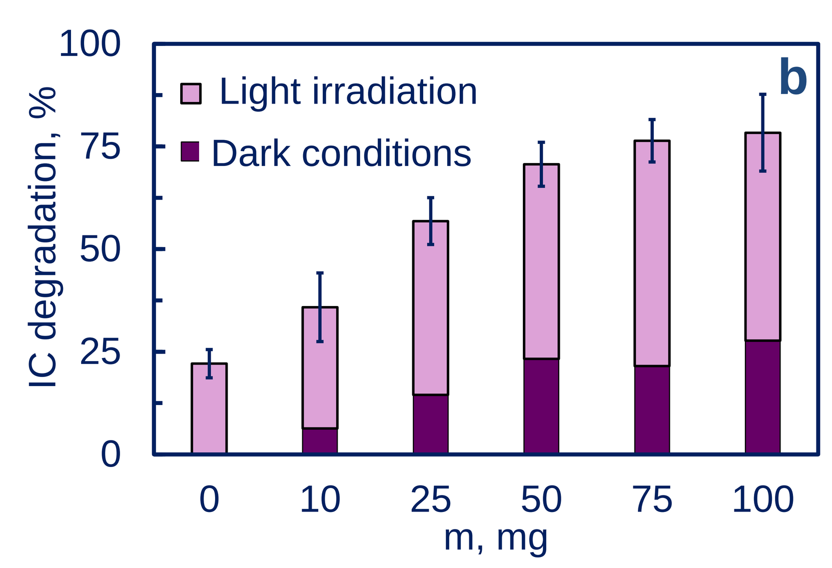


Fig. 4 Effect of «co-precip.» mass on the IC degradation activity

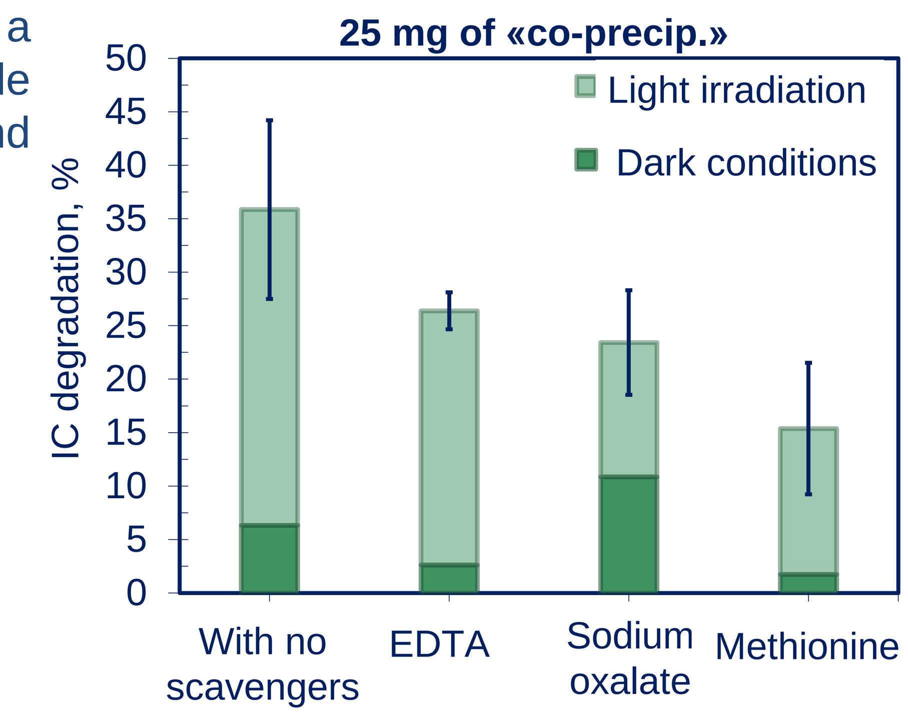


Fig. 5 Photocatalytic activity tests in the presence of different scavengers

Singlet oxygen plays a dominant role in the degradation process of indigo carmine (Fig. 5). Most likely mechanism of the reaction:

$$H_2O_{2(ads.)} = H\bullet_{(ads.)} + \bullet OOH_{(ads.)}$$
$$H_2O_{2(liq)} + \bullet OOH_{(ads.)} = H_2O_{(liq)} + {}^1O_{2(liq)} + \bullet OH_{(liq)}$$
$$IC_{(liq)} + {}^1O_{2(liq)} = CO_2 + H_2O$$

CONCLUSIONS

1. H_2O_2 significantly intensifies the process: 70% dye destruction in 60 min (0.01 mol/L H_2O_2, 50 mg photocatalyst).
2. Singlet oxygen ($^1O_2$), formed via dissociative adsorption of H_2O_2 on the ferrite surface, is the key oxidant for indigo carmine; the contribution of hydroxyl radicals (•OH) is negligible.