PLASMA-SOLUTION SYNTHESIS OF TRANSITION METAL FERRITES[*]

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Spinel ferrites ($Me^{2+}Fe_2O_4$; Me^{2+}= Co, Ni, Cu, Zn…) are a large group of materials with a uniquely wide range of electronic, magnetic, chemical properties [1]. It is well known that their properties directly depend on the synthesis method. According to existing literature data, low-temperature plasma interacting with liquids is characterized by high productivity (~ mg/min) [2] and can be used to synthesize materials with new crystallographic phases. Despite scientists' advantages and interest in plasma-solution syntheses, the mechanisms of the formation of nanoparticles, incredibly complex oxides, have not been thoroughly studied.

The plasma-solution system was an H-shaped glass cell, the arms of which were separated by a membrane. The electrodes were placed in the gas phase at a distance of 5 mm from the surface of the solution. Aqueous solutions of Iron(III) Nitrate with the addition of Co(II), Ni, Cu, and Zn nitrates were used as the liquid phase. Initial concentrations varied over a wide range. In Table 1, the concentrations for obtaining ferrites of the composition $NiFe_2O_4$, $CoFe_2O_4$, $CuFe_2O_4$, $ZnFe_2O_4$, and a spinel-type structure were presented, as well as the results of a morphological study of the resulting compounds were presented there. The synthesis process was described in detail in the article [4].

The morphology and composition of the obtained samples were studied using SEM (Tescan Vega 3SBH, Czech Republic), EDX (Aztec EDX, Oxford Instruments Ltd., England), XRD (DRON 3M, Burevestnik, Russia, CuKa radiation). The kinetics of particle formation and sedimentation processes were studied using turbidimetric analysis (laser wavelength 632,8 nm, transmitted light receiver AvaSpec-2048FT-2 spectrometer, Avantes, Netherlands). The particle size was obtained using DLS (Photocor Compact-Z, Photocor, Russia).

Table 1. Oxide metal particles synthesis in plasma solution system. Discharge current 40 mA.

Type of particles after calcination	Raw materials of solutions	Initial concentration, mmol/l	Particle size		Rate constant, s^{-1}		XRD and EDS of precursor
			The 1st fraction, nm	The 2nd fraction, μm	30 mA	70 mA	
$NiFe_2O_4$	$Ni(NO_3)_2$	50	42.3	0.20	$1.9\cdot10^{-3}$	$2.2\cdot10^{-3}$	$Ni(OH)_2$; $Fe(OH)_3$; $Fe(OH)_2(NO_3)$
	$Fe(NO_3)_3$	2					
$CuFe_2O_4$	$Cu(NO_3)_2$	50	23	0.97	$5.9\cdot10^{-3}$	$12,5\cdot10^{-3}$	$Cu(NO_3)(OH)$; $Cu(OH)_2$; $Fe(OH)_3$; $Fe(OH)_2(NO_3)$
	$Fe(NO_3)_3$	2					
$ZnFe_2O_4$	$Zn(NO_3)_2$	50	95.4	1.8	$5.2\cdot10^{-3}$	$9.3\cdot10^{-3}$	$Zn(OH)(NO_3)$; $Zn(OH)_2$; $Fe(OH)_3$; $Fe(OH)_2(NO_3)$
	$Fe(NO_3)_3$	4					
Cubic $CoFe_2O_4$	$Co(NO_3)_2$	50	92.9	1.4	$7.4\cdot10^{-3}$	$20\cdot10^{-3}$	$Co(OH)_2$; $Fe(OH)_3$; $Fe(OH)_2(NO_3)$
	$Fe(NO_3)_3$	3					

Thus, the work presents primary data on producing ultrafine particles of transition metal ferrites from solutions under the action of low-temperature gas-discharge plasma.

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