IR absorption spectra of (2–X)MgO·X(MnO, FeO)·$2Al_2O_3$·$5SiO_2$ (X=0–2) ceramic materials

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An magnesium aluminosilicate $Mg_2Al_4Si_5O_{18}$ is a high thermal stability and electrical insulating ceramic material (cordierite). $Mg_2Al_4Si_5O_{18}$ is commonly synthesized at temperatures from 1350 to 1450°C. We examined the effect of MnO and FeO modifiers on the processes of phase formation in the $2MgO\cdot2Al_2O_3\cdot5SiO_2$ system [1]. (2–X)MgO·X(MnO, FeO)·$2Al_2O_3$·$5SiO_2$ (X=0–2) ceramic materials were prepared through partial (X<2) or complete (equimolecular X=2) substitution of MnO or FeO for MgO in a magnesium aluminosilicate system. Samples were synthesized using standard ceramic technology at temperatures of 1050–1250°C [2]. The study is aimed at analyzing the phase structure in the studied system by IR spectroscopy method (Nexus Fourier transform IR spectrometer Thermo, USA). The IR spectra of the materials studied show many absorption bands in the range 400–1300 cm^{-1}. The strongest band, situated at 920–1198cm^{-1}, is mainly due to the asymmetric and symmetric modes of the tetrahedral bond Si–O–Si, common to all silicates. At a sintering temperature as low as 1100°C for the manganesecontaining samples and 1150°C for the ironcontaining samples, the spectra show well defined absorption bands characteristic of rings of [SiO_4]-tetrahedra in the structure of silicates: a strong doublet in the range 912–1180 cm^{-1}, due to the asymmetric stretching mode of the Si–O–Si bond of the [SiO_4]-tetrahedral group. The “ring” band at 766–770 cm^{-1} and the band at 572–578 cm^{-1} are attributable to the formation of six tetrahedras, [Si_6O_{18}] or [Si_5AlO_{18}], characteristic of the $Mg_2Al_4[Si_5AlO_{18}]$, $Mn_2Al_4[Si_5AlO_{18}]$, and $Fe_2Al_4[Si_5AlO_{18}]$ silicates, which have a ring structure of the silicon–oxygen radical, and of their solid solutions. Mn^{2+} and Fe^{2+} substitution for Mg^{2+} influences the distortion of the tetrahedra, their spatial arrangement, and the shift of the bands characteristic of $Mg_{2-y}Mn_yAl_3[Si_5AlO_{18}]$ and $Mg_{2-y}Fe_yAl_3[Si_5AlO_{18}]$ to lower frequencies (1167, 1147, 950, 912, 766, 614, 575 and 1162, 1145, 950, 900, 726, 611, 558 cm^{-1}) relative to the absorption bands of $Mg_2Al_4[Si_5AlO_{18}]$ (1180, 1147, 955, 914, 770, 616, and 577 cm^{-1}). The bands at 1164, 1126, 1084, 950, 738, and 557 cm^{-1} in the spectrum of material were prepared through complete (X=2) substitution and synthesized at 1100°C are attributable to the formation of rings of four tetrahedras, [Si_4O_{12}] or [Si_3AlO_{12}], in the structure of $Mn_3Al[Si_3AlO_{12}]$. The IR spectroscopy results are consistent with the XRD data and indicates that MnO and FeO accelerate the phase formation of $Mg_{2-y}(Mn, Fe)_yAl_4Si_5O_{18}$, which is similar in XRD pattern to $Mg_2Al_4Si_5O_{18}$ [2].

References

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[2] O.I. Salychits, S.E. Orekhova Inorg. Mater. (2011) 47:899