Chemical Composition of Interstellar Amorphous Silicate Dust

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Absorption features at ~10 μm and ~18 μm of interstellar dust indicate the majority of interstellar silicate dust is amorphous and the upper limit to the fraction of crystalline silicates in the diffuse interstellar medium is 2.2 ± 0.2 % by mass [1, 2]. Synthetic optical constants such as "astronomical silicate" [3] and "interstellar dust" [4] have been widely used in the interpretation of observational data. These optical properties, however, do not represent real solid materials because they are arbitrarily synthesized from the combination of the observation and laboratory data. Various dust analogs have been produced in laboratories [e.g., 5, 6] but still cannot replace the astronomical silicates. Thus, the nature of amorphous silicate dust in the circumstellar and interstellar environments, such as chemical composition and structure, cannot be derived from discussions using astronomical silicates.

In this study, we conducted gaseous condensation experiments of dust analog nanoparticles in the system of Na-Al-Ca-Mg-Fe-Ni-Si-O using the induction thermal plasma (ITP) system (JEOL TP-40020NPS, [7]). The chemical compositions of the starting materials are shown in Table 1. The products were analyzed by XRD (Rigaku RINT-2100), FT-IR (JASCO FT/IR-4200), and EPMA (JEOL JXA-8530F) and partly observed by TEM (JEOL JEM-2800). We report IR spectral dependence on the chemical compositions of amorphous silicates and discuss the chemical composition of interstellar silicates by comparing the experimental products with astronomical silicates and observations.

Table 1: Chemical Composition of the Starting Material

	Mg	Si	Al	Ca	Na	Fe	Ni
$Ca_{0.06}MgNa_{0.06}Al_{0.08}Si$ w/ Fe, Ni	1.03	1	0.08	0.06	0.06	0.85	0.05
$Ca_{0.06}MgNa_{0.06}Al_{0.08}Si$ w/o Fe, Ni	1.03	1	0.08	0.06	0.06	-	-
$MgAl_xSi$(x=0.75) w/ Ca, Na	1.03	1	0.75	0.06	0.06	-	-
$MgAl_xSi$ (x=0.64)	1.03	1	0.64	-	-	-	-
$MgAl_xSi$ (x=0.31)	1.03	1	0.31	-	-	-	-
$MgAl_xSi$ (x=0.08)	1.03	1	0.08	-	-	-	-
$Ca_{0.5}Mg_{0.5}Al_xSi$ (x=0.08)	0.515	1	0.08	0.515	-	-	-
$CaAl_xSi$ (x=0.08)	-	1	0.08	1.03	-	-	-
$CaAl_xSi$ (x=0.64)	-	1	0.64	1.03	-	-	-

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