No. 41A-5 NH_4LiSO_4, Ammonium lithium sulfate

(M = 121.04; [D: 125.07])

1a Ferroelectric activity in NH_4LiSO_4 was discovered by Mitsui et al. in 1975. 75Mit

b

phase	V	IV	III	II	I
state			P	F	P
crystal system			monoclinic	orthorhombic	orthorhombic
space group			$P2_1/c11$ [a]) $-C_{2h}^5$	$P2_1cn$ [b]) $-C_{2v}^9$	$Pmcn$ [c]) $-D_{2h}^{16}$
Θ [K]		81.3 [g])	133 [f])	283 [d])	459.7 [e])

[a]) 93Mas
[b]) 69Dol
[c]) 81Ito
[d]) 58Pep
[e]) 75Mit
[f]) 78Wat
[g]) 82Rey

$P_s \parallel [100]$. 81Ito
$\rho_X = 1.896 \cdot 10^3$ kg m^{-3} at RT, 93Mas
$\rho_X = 1.933 \cdot 10^3$ kg m^{-3} at 478 K. 81Ito
Colorless.
Pressure induced phases:

phase	VI	VII
crystal system	monoclinic	triclinic
space group	$P2_111-C_2^2$	
transition pressure [$\cdot 10^8$ Pa]	6.5	12.4

94Has

A new monoclinic phase below 28 K has been reported; see 84Sim
Deuterated crystal: space group at 323 K: $Pc2_1n-C_{2v}^9$. 89Fis

2a Crystal growth: evaporation method from an aqueous solution at about 30 °C. 77Shi
Evaporation from an equimolar aqueous solution of $(NH_4)_2SO_4$ and $Li_2SO_4 \cdot H_2O$. 81Ito
Crystal growth in low temperature region below 297 K gives α-form of NH_4LiSO_4 which has three forms A, B and C. Crystal systems and space groups of the form A, B and C are orthorhombic $Pca2_1-C_{2v}^5$, monoclinic $P12_1/a1$ or $P12_1/c1-C_{2h}^5$ and orthorhombic $Pcca-D_{2h}^8$, respectively. Length of the a axis in the forms B and C becomes twice and three times of the form A, respectively.
See 91Pie, 92Tom, 90Sos

3a Unit cell parameters:
Phase I: a = 5.299(2) Å, b = 9.199(2) Å, c = 8.741(3) Å at 478 K. 81Ito
Phase II: a = 5.280(2) Å, b = 9.140(7) Å, c = 8.786(6) Å at 298 K. 69Dol
a = 5.282(1) Å, b = 9.131(3) Å, c = 8.780(2) Å at 298 K. 93Mas
Phase III: a = 5.274(2) Å, b = 9.130(6) Å, c = 17.511(6) Å, α = 90.00(3)° at 213 K. 78Kru
a = 5.283(2) Å, b = 9.121(5) Å, c = 17.444(7) Å, α = 90.00(4)° at 190 K. 93Mas
Phase VI: a = 5.277(2) Å, b = 8.984(4) Å, c = 8.656(3) Å, α = 90.31(2)° at 9.5 $\cdot 10^8$ Pa and T = RT. 94Has

	Phase VII: a = 31.444(9) Å, b = 18.168(8) Å, c = 8.456(3) Å, $\lvert\alpha - 90°\rvert$, $\lvert\beta - 90°\rvert$, $\lvert\gamma - 90°\rvert < 0.1°$ at $14.5 \cdot 10^8$ Pa and T = RT.	94Has
	Deuterated crystal: a = 9.1310(15) Å, b = 5.2786(9) Å, c = 8.7710(8) Å at 323 K.	89Fis
b	Z = 4 in phase I.	81Ito
	Z = 4 in phase II.	69Dol
	Z = 8 in phase III.	93Mas
	Z = 4 in phase VI.	94Has
	Z = 48 in phase VII.	94Has
	Crystal structure of phase I: Arrangement of SO_4 and LiO_4 tetrahedra viewed along c: Fig. 41A-5-001. Electron density map: Fig. 41A-5-002. Fractional coordinates and isotropic temperature factor: Table 41A-5-001. Interatomic distances and bond angles: Table 41A-5-002. Crystal structure of phase II: Table 41A-5-003, Table 41A-5-004; Fig. 41A-5-003, Fig. 41A-5-004. Crystal structure of phase III: Table 41A-5-005, Table 41A-5-006, Table 41A-5-007; Fig. 41A-5-005, Fig. 41A-5-006. Crystal structure of pressure induced phase VI: Table 41A-5-008; Fig. 41A-5-007, Fig. 41A5-008, Fig. 41A-5-009. Crystal structure of deuterated crystal: Table 41A-5-009.	
4	Thermal expansion: Fig. 41A-5-010, Fig. 41A-5-011, Fig. 41A-5-012. Thermal expansion coefficient: Fig. 41A-5-013, Fig. 41A-5-014, Fig. 41A-5-015, Fig. 41A-5-016.	
5a	Temperature dependence of dielectric constant: Fig. 41A-5-017, Fig. 41A-5-018, Fig. 41A-5-019, Fig. 41A-5-020, Fig. 41A-5-021.	
	See also	74Yuz, 75Ale, 75Hil, 80Loi, 82Ger
	Effect of deuteration: see Fig. 41A-5-017. Effect of hydrostatic pressure: Fig. 41A-5-022, Fig. 41A-5-023. Phase diagram with respect to p: Fig. 41A-5-024, Fig. 41A-5-025, Fig. 41A-5-026.	
	See also	77Shi, 77Ale1, 80Nak
c	Spontaneous polarization: Fig. 41A-5-027, Fig. 41A-5-028.	
	See also Effect of deuteration: see Fig. 41A-5-028.	82Ger
d	Pyroelectric coefficient: see	80Loi
6a	Specific heat capacity: Fig. 41A-5-029. For ND_4LiSO_4: Fig. 41A-5-030.	
	See also	86Wys
8a	Elastic stiffness constants: By ultrasonic method $1.0 \cdot 10^7$ Hz: Table 41A-5-010; Fig. 41A-5-031. By Brillouin scattering: Fig. 41A-5-032, Fig. 41A-5-033. Comparison with ultrasonic measurements: Fig. 41A-5-034, Fig. 41A-5-035. See also Fig. 41A-5-043, Fig. 41A-5-044 in 10b. Ultrasonic attenuation coefficients at $2.0 \cdot 10^7$ Hz: Fig. 41A-5-036.	

9a	Optical absorption:	
	Mn^{2+} ions: see	84Ven
	Co^{2+} ions: see	83Har
	Cr^{3+} ions: see	83Lak
	Refractive indices: Fig. 41A-5-037.	
10a	Raman scattering: Fig. 41A-5-038, Fig. 41A-5-039, Fig. 41A-5-040, Fig. 41A-5-041, Fig. 41A-5-042.	
	Under hydrostatic pressure: see	82Pol
	For partially deuterated crystal: see	86Tor
b	Brillouin scattering: Fig. 41A-5-043, Fig. 41A-5-044.	
	See also Fig. 41A-5-032, Fig. 41A-5-033 in 8a.	
	See also	85Lus, 83Yam, 81Hir, 87Sch2
13a	NMR:	
	Spin-lattice relaxation time T_1 of ^1H: Fig. 41A-5-045, Fig. 41A-5-046, Fig. 41A-5-047.	
	Spin-lattice relaxation time $T_{1\rho}$ of ^1H: see Fig. 41A-5-047.	
	See also	82Rey
	Spin-lattice relaxation time T_1 of ^7Li: Fig. 41A-5-048.	
	NMR under high pressure: see	77Ale2
	See also	79Vog
	Proton second moment: Fig. 41A-5-049.	
	Quadrupole splitting of ^7Li: Fig. 41A-5-050.	
b	ESR of NH_3^+: Fig. 41A-5-051, Fig. 41A-5-052, Fig. 41A-5-053.	
	CrO_4^{3-}: Fig. 41A-5-054.	
	ESR of CrO_4^{3-} in deuterated crystals: Fig. 41A-5-055.	
14	Temperature dependence of X-ray diffraction at low temperature: Fig. 41A-5-056.	
15a	Domain structure: see	75Hil
b	Effects of mechanical stress: see	75Hil
	Ferroelectric domain structure was observed with a scanning electron microscope in phases II and III: see	86Mau
	Ferroelectric domain in phases II was observed by etching method [a]) [b]), scanning electron microscope [b]), nematic liquid crystal [b]) and decoration technique [c]).	[a]) 92Pol [b]) 93Pol [c]) 89Hil
	Ferroelastic domain in phase III was observed by polarized light.	75Hil
	Domain switching time: Fig. 41A-5-057.	
16	Etchant for revealing domain: water.	92Pol
	A regular large-scale domain-like structure was observed in the close vicinity of T_c: see	94Pol