Superconductivity of multicomponent molybdenum sulfides

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A number of new superconducting molybdenum sulfides with formula $Mo_6M_xS_8$ have been observed, the third component M being an alkali metal, carbon, or a rare-earth element.

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Superconductivity of three-component molybdenum sulfides with composition in the form $M_xMo_6S_8$, where M = Pb, Sn, Ag, Cu, Zn, Mg, Cd, Sc, and Y, have been recently reported.[1–7]

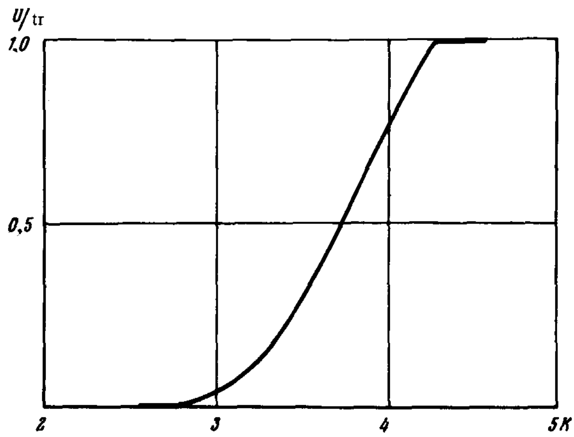
We have investigated similar systems with certain other elements *M*. In addition to the already known compounds, superconductivity was observed in systems with alkali metals and with carbon. In addition, we investigated a number of compounds with rare-earth elements, many of which turned out to be superconducting.

The table lists the critical temperatures of the obtained compounds. The transitions to the superconducting state were revealed both by the change of the inductance and by the change of the dc resistance.

The figure shows the transition curve for one of the $Mo_6Li_2S_8$ samples. Unlik the other systems, the samples with alkali metals were not subjected to homogenizing annealing and this is probably why their transitions to the superconducting state are greatly stretched out.

As is well known, introduction of Al, Ga, or Nb into Mo_5SnS_6 increases its critical temperature.[4,8] From our data listed in the table it is seen that boror scandium, and lanthanum, when used as the fourth component, lead to an increase of T_c in the Mo_5SnS_6 system. There are, however, a number of element that lower the T_c of Mo_5SnS_6, for example $T_c = 9.3$ °K for $Mo_5SnTl_{0.5}S_6$.

The most abrupt decrease of T_c is caused by ferromagnetic metals, since the introduction of the iron leads to a linear decrease of the critical tempera-



ture of Mo_5SnS_6, with a derivative $dT_c/dc = 22$ °K/at. %. These data are in good agreement with [5]. It should be noted that in this case the influence of the ferromagnetic impurities is stronger than, for example, for superconductors with β-W structure. [9]

Composition	T_c, K	Composition	T_c K
$Mo_6Li_2S_8$ [a]	4.2 ÷ 3.5	$Mo_6Sm_6S_8$ [b]	< 0.6
$Mo_6Na_2S_8$	8.6 ÷ 8.0	$Mo_6Ce_2S_8$	< 0.6
$Mo_6K_2S_8$	2.7	$Mo_6Dy_2S_8$	2.1
$Mo_6Rb_2S_8$	< 0.6	$Mo_6Gd_2S_8$	2.2
$Mo_6Cs_2S_8$	< 0.6	$Mo_6Nd_2S_8$	3.45 - 3.2
Mo_5SnS_6	10.8	$Mo_6Yb_2S_8$	8.18 - 7.3
$Mo_5SnB_{0.5}S_6$	12.3	$Mo_6Er_2S_8$	2.19
$Mo_5SnY_{0.5}S_6$	9.95 - 7.65	$Mo_5C_xS_6$ [c]	3.5 - 4.14
$Mo_5SnSc_{0.5}S_6$	11.4 - 12.0	$0.5 \leqslant x \leqslant 2$	
$Mo_5SnLa_{0.5}S_6$	12.2 - 11.4	$Mo_5Sc_xS_6$	2.6 - 2.8
$Mo_5SnTl_{0.5}S_6$	9.3 - 8.1	$1 \leqslant x \leqslant 2$	
		$Mo_5Y_xS_6$	2.5 - 2.6
		$0.5 \leqslant x \leqslant 2$	

a) For all samples containing alkali metals, an analysis has shown that the concentration of the Mg and Fe impurities did not exceed 10^{-2}%, and the concentration of the other impurity metals was less than 10^{-3}%.

b) The superconductivity of systems with rare-earth elements was investigated in [7]. Some difference between our values of T_c and those of [7] appears to be due to differences in the sample preparation.

c) It is interesting that T_c of the $Mo_6C_xS_8$ system increases with decreasing x down to $x = 0.5$.

It can be presently assumed that most metals from groups I to IV of the periodic system, when introduced into the Mo_6S_8 system as a third component, lead to the onset of superconductivity, and in a number of cases high critical temperatures and magnetic fields are obtained in such compounds. However, certain metals (Ga, Al) used as the third component lower the magnetic order, [10] and the $R(T)$ dependence has in this case a superconducting character. Our x-ray investigations have shown that magnetic compounds should also be classified as Chevreul phases, which in this case, in contrast to most superconducting systems, have $c/a<1$, that is, a rhombohedral angle exceeding 90°.

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