Impurity Diffusion in Isotopic ^{6}Li and ^{7}Li Metal

A. Ott and A. Lodding

Physics Department, Chalmers University of Technology, Gothenburg, Sweden

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The mobilities of foreign metal tracers in isotopically pure lithium matrices have been studied. Differential diffusivities have been obtained for Na, Ag, Au, Zn and Ga in Li. The behaviour of impurities whose diffusion is not of a regular vacancy character (Au, Ag, Zn) appears connected with the quantum effects in Li self-diffusion.

A recently developed method of mass effect study in diffusion, practicable especially for tracer mobilities in lithium, makes use of the possibility of varying the isotope mass of the matrix. Such a technique has been used for Li isotope interdiffusion studies [1], and preliminary results have also been published for ^{195}Au in ^{6}Li and ^{7}Li metals [2]. The latter investigation has since been extended to a greater temperature interval [3]. Recently differential diffusivity has also been measured for Na, Ag, Zn and Ga in isotopic Li. The Na and Au results have been presented this year in connection with a discussion of the method and the formalism of its evaluation [4].

The present note is intended as a brief summary of hitherto obtained data on the differential diffusivity of impurities in ^{6}Li and ^{7}Li. In Table 1, the symbol $_7{}^6E$ denotes the ratio $({}^6D_M - {}^7D_M)/{}^7D_M$, where ${}^6D_M$ is the diffusion coefficient of the tracer M in pure ^{6}Li, and ${}^7D_M$ that of the same tracer in ^{7}Li. The actual experiments were conducted in imperfectly separated matrices, containing 5% resp. 92.5% ^{7}Li, but the listed $_7{}^6E$ values have been extrapolated to 100% isotopic purity.

In the discussion of Ref. [4] a significant distinction was pointed out between the differential diffusivity behaviour of Na in Li on one hand, Au in Li on the other. For Na the values of $_7{}^6E$ remain below the "classical" inverse root of mass limit $\sqrt{7/6}-1$ (i. e. ca. 8%), exhibiting only a very slight temperature dependence. This could be reconciled with the vacancy mechanism of diffusion. On the other hand Au in Li shows a marked temperature dependence of $_7{}^6E$, at the lowest temperatures increasing considerably beyond the 8% limit. It was argued in Ref. [4] that this is incompatible with straightforward vacancy diffusion as well as with simple interstitial motion. A mechanism was suggested in which the mobility of the tracer was coupled with that of the Li matrix atoms, also implying at least intermittent occupancy of interstitial sites by the tracer.

It can be seen in Table 1, that Ag in Li even at the highest temperatures exceeds the 8% limit of $_7{}^6E$. Zn in Li suggests a similar tendency at somewhat lower temperatures. Ag and Zn thus appear to belong to the same category as Au in regard of differential diffusivity in isotopic Li. This is in agreement with other evidence [5–8] to the effect that these three tracers are at least partially interstitial, while Na probably diffuses conventionally via vacancies. The data for Ga in Li are so far not conclusive.

Tracer	T (°C)	$_7{}^6E$ (%)	Tracer	T (°C)	$_7{}^6E$ (%)
^{22}Na	175.0	4±2	^{65}Zn	157.5	7±2
	163.5	3±2		153.8	7±2
	158.1	5±2		147.8	6±2
	156.5	4±2		141.8	8±2
	150.9	4±2	^{72}Ga	173.4	6±2
	135.3	3±2		156.5	5±2
	121.5	7±3			
	69.9	7±3			
^{110m}Ag	169.8	9±2			
	134.5	9±2			
	77.9	12±3			
^{195}Au	177.0	5±2			
	167.9	4±2			
	141.8	5±2			
	125.9	8±2			
	100.8	7±2			
	98.1	9±2			
	60.5	14±3			
	37.2	16±4			
	27.9	15±3			

Table 1. Differential diffusion of impurities in isotopically separated Li metal.

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