JPEDAV (2005) 26:80
DOI: 10.1361/15477030522581
1547-7037/$19.00 ©ASM International

The Hg-Ra (Mercury-Radium) System

C. Gumiński

The Hg-Ra phase diagram is not known. The melting points of Hg and Ra are −38.8290 and 700 °C, respectively. Information about the crystallographic features of both metals is given in Table 1. [1910Cur] prepared ~0.8 at.% Ra amalgam by electrolysis. It looked completely fluid at room temperature. When heated, it became solid at 400 °C and emanated the rest of the Hg at 700 °C.

[1962Koz] calculated the solubility of Ra in liquid Hg of 1.1 at.% Ra at 25 °C using a semiempirical equation relating metal solubility to its entropy of melting. Calculations by the same author [1992Koz], using a regular solution approximation and the cellular model of Miedema et al. [1983Nie], resulted in solubility values both equal to 0.5 at.% Ra. In the opinion of this evaluator, these estimations give the proper order of magnitude for Ra solubility.

One may predict a probable Hg-Ra phase relationships by an extrapolation of the systematic changes in the behavior of Mg, Ca, Sr, and Ba in their binary alloys with Hg [2004Gum]. A distinct tendency to formation of the Hg-richer compounds is observed with an increase in the atomic number of the alkaline earth metal series. Therefore, it is not clear whether $HgRa_2$ exists, but most probably the congruently melting HgRa and Hg_2Ra compounds should be the most stable phases of the Hg-Ra system. Moreover, a formation of $Hg_{31}Ra_7$, $Hg_{11}Ra$, and $Hg_{\sim 6}Ra$, by analogy to the Ba-Hg compounds, is expected. [1992Koz] reported the formation of HgRa, Hg_2Ra, and Hg_4Ra, but the experimental evidence underlying this report is unknown.

Strong affinity between Hg and Ra is manifested in the partial excess Gibbs energy of Ra in its very diluted amalgam. This energy was found to be −255 ± 10 kJ/mol Ra near room temperature, and −243.8 kJ/mol Ra at 25 °C, respectively, according to [1975Nug] and [1990Kor]. These values point to stronger Hg-Ra interactions in the Hg-rich Ra-Hg alloys than was observed in the Ba-Hg system [2000Gum]. The partial excess Gibbs energy was calculated from the difference between the standard potential of Ra/Ra(II) and the polarographic half-wave potential of Ra, which was experimentally determined by a radiopolarographic method [1975Nug]. [1977Koz] reported the partial excess Gibbs energy (−250 kJ/mol) and enthalpy (−313 kJ/mol) of Ra in its diluted amalgam by an extrapolation of the corresponding values for Ca, Sr, and Ba compared with the electronegativity or atom radii of these elements to the position of Ra. Because neither the electronegativity nor the atomic radius of Ra is precisely known, the strongly negative partial enthalpy value should be treated very tentatively.

The activity coefficient of Ra in a dilute amalgam was estimated by [1989Gum] to be on the order of 10^{-45}. This also points to a very strong interaction between Hg and Ra.

References

1910Cur: M. Curie and A. Debierne, Metallic Radium, *Compt. Rend.,* Vol 151, 1910, p 523-525 (in French) (Experimental)

1962Koz: L.F. Kozin, Solubility of Metals in Hg, *Tr. Inst. Khim. Nauk Akad. Nauk Kaz. SSR,* Vol 9, 1962, p 101-121 (in Russian) (Theoretical)

1975Nug: L.J. Nugent, Standard Electrode Potentials and Enthalpies of Formation of Some Lanthanide and Actinide Aquo-ions, *J. Inorg. Nucl. Chem.,* Vol 37, 1975, p 1767-1770 (Experimental)

1977Koz: L.F. Kozin, R.Sh. Nigmetova, and M.B. Dergacheva, The Ra-Hg System, *Thermodynamics of Binary Amalgam Systems,* Nauka, Alma-Ata, 1977, p 153-157 (in Russian) (Review)

1983Nie: A.K. Niessen, F.R. de Boer, R. Boom, P.F. de Châtel, W.C.M. Mattens, and A.R. Miedema, Model Predictions for the Enthalpies of Formation of Transition Metal Alloys, *Calphad,* Vol 7, 1983, p 51-70 (Theoretical)

1989Gum: C. Gumiński, Selected Properties of Simple Amalgams, *J. Mater. Sci.,* Vol 24, 1989, p 2661-2676 (Review)

1990Kor: V.N. Korshunov, Equilibrium Potentials of Simple Amalgams, *Amalgam Systems,* Izdatelstvo Moskovskogo Univesiteta, Moskva, 1990, p 53 (in Russian) (Review)

1992Koz: L.F. Kozin, Solubility of Metals in Hg, *Physical Chemistry and Metallurgy of High Purity Hg and Its Alloys,* Naukovaya Dumka, Kiev, 1992, p 42-43 and 70 (in Russian) (Review)

2000Gum: C. Gumiński, The Ba-Hg System, *J. Phase Equilibria,* Vol 21, 2000, p 173-178 (Review)

2004Gum: C. Gumiński, Contribution of Electrochemistry to the Knowledge on Structure and Properties of Amalgams, *Polish J. Chem.,* Vol 78, 2004, p 1733-1751 (Review)

Table 1 Crystal structure and lattice constants of Hg and Ra

Phase	Composition, at.% Ra	Pearson symbol	Space group	Strukturbericht designation	Prototype	Lattice constants (*a*), nm	Temperature, °C	Reference
Hg	0	*hR*1	$R\bar{3}m$	*A*10	αHg	0.3005 α = 70.53°	−48	[Massalski2]
Ra	100	*cI*2	$Im\bar{3}m$	*A*2	W	0.5148	RT	[Massalski2]

Hg-Ra evaluation contributed by **C. Gumiński,** Department of Chemistry, University of Warsaw, Pasteura 1, 02093 Warszawa, Poland. This work was supported by ASM International. Literature was searched through 2003. Dr. Gumiński is the Alloy Phase Diagram Program Category Editor for the binary mercury alloys.