METHODS OF DETERMINING THE COMPOSITION OF AMALGAMS.

M. G. MELLON, Purdue University.

While working with lead amalgams, it became necessary to make a search of the entire literature relating to the scientific study of amalgams in order to ascertain what methods have been used in determining their quantitative composition. Since the titles and the abstracts of the articles found rarely indicated anything concerning analytical methods, the papers themselves had to be read. It is hoped this bibliography may save others a similar expenditure of time.

More than 850 references were found, of which about 75 per cent were read. The remainder could not be consulted because of inaccessibility, incorrect statements of the reference, or unfamiliar languages, such as Russian, Scandinavian and Dutch. It is believed, however, that the present report is fairly complete.

Although the earlier references of this list go back to 1750, little of value was located until the work of Davy in 1808. In many cases the amalgams were stated to have a given composition, but no method of analysis was given. No effort was made to locate every reference mentioning incidental uses of amalgams, such as their application in certain physico-chemical measurements and in organic chemistry as reducing agents, or to cover their industrial application in such operations as metallurgy, electrochemistry and dentistry. No mention is made of the cases in which the elements composing the amalgam were weighed directly and its composition calculated from these weights. Practically all the references deal with binary amalgams.

Types of Methods. The various procedures used in determining the composition of amalgams have been classified according to the following outline:

I. Gravimetric Methods—

1. Gas-evolution processes—those in which either the mercury or the other constituent was volatilized; or in which the amalgam reacted with a solution to evolve an amount of a gas equivalent to the element in the mercury. The amount of desired constituent was calculated from the weight of residue or from the volume of the evolved gas.

2. Gravimetric precipitation processes—those in which the desired constituent was separated and subsequently weighed in the form of an insoluble precipitate.

3. Solution and extraction processes—those in which one of the elements was dissolved out with an appropriate solvent. The element undissolved was weighed as such, or the one dissolved was determined by evaporating the extract to dryness under suitable conditions and weighing the residue.

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II. Titrametric Methods—

1. Neutralization processes—those in which the desired constituent was dissolved out of the amalgam by means of water or an excess of a standard acid and the solution then titrated with an acid or base, respectively.

2. Oxidation-reduction processes—those in which the desired constituent was dissolved out and determined by means of a suitable oxidizing or reducing solution.

3. Titrametric precipitation processes—those in which the desired constituent was dissolved out and determined by means of a suitable solution forming a precipitate with the constituent.

III. Electrolytic Methods—

1. Direct processes—those in which the element was deposited upon an electrode in the usual manner and weighed.

2. Indirect processes—those in which the element was deposited in a weighed amount of mercury, the amount deposited being calculated according to Faraday's law from the weight or volume of some other element liberated in a coulometer placed in series in the same electrical circuit.

IV. Physico-Chemical Methods—

This group includes those processes involving the measurement of some physical property of the system investigated which is a function of the concentration of the desired constituent. Such properties of amalgams include density, electrode potential and color.

SUMMARIZED INFORMATION

Element Det'd	Method	Quantity Measured	References
NH_3	Grav.—Gas.-Evol.	NH_3 H_2	23, 44, 58, 77
	Grav.—Sol.-Extr.	....	80
	Titr.—Neutr.	Vol.	59, 69
Al	Grav.—	Al_2O_3	66, 102
	Grav.—Gas-Evol.	H_2	102
As	Titr.—Oxid-Red	Vol.	19
Ba	Grav.—Pptn.	$BaSO_4$	66, 83, 86
	Grav.—Pptn.	$BaCrO_4$	84
	Titr.—Neutr.	Vol.	89, 90, 103
	Titr.—Pptn.	Vol.	93
Bi	Grav.—Pptn.	Bi_2O_3	17
	Grav.—Sol.-Extr.	Bi_2O_3	34
Cd	Grav.—Pptn.	CdO	7
	Grav.—Gas-Evol.	CdO	35
	Grav.—	CdO	96, 99
	Elec.—F's Law	Time-Amp.	13, 94, 97
	Phys-Chem	Density	32, 72
	Phys-Chem	E.M.F.	57, 103
Cs	Grav.—Pptn.	Cs_2PtCl_6	85, 87
	Titr.—Neutr.	Vol.	43, 89, 90, 103
Ca	Grav.—Pptn.	CaO	79, 84
	Grav.—Gas-Evol.	CaO	28
	Titr.—Neutr.	Vol.	8, 89, 90, 103
	Titr.—Pptn.	Vol.	93

SUMMARIZED INFORMATION—Continued

Element Det'd	Method	Quantity Measured	References
Cr	Grav.—Gas-Evol.	Cr_2O_3	20
Co	Grav.—Gas-Evol.	Co	62
Cu	Grav.—Gas-Evol.	CuO	34, 73, 76
	Elec.—F's Law	H_2	56
	Elec.—F's Law	Ag	73, 76
	Elec.—F's Law	Time-Amp.	94, 97
	Phys.—Chem.	Color	73, 76
Au	Grav.—Sol-Extr	Au	10, 12, 96
	Grav.—Gas-Evol.	Au	101
	Phys-Chem.	E.M.F.	57
In	Elec.—F's Law	Ag	76
Fe	Grav.—Gas-Evol.	Fe	62
	Grav.—Gas-Evol.	Fe_2O_3	73, 76
Pb	Grav.—Pptn.	$PbSO_4$	3, 26, 30, 34, 37
	Grav.—Pptn.	$PbCrO_4$	51, 53
	Grav.—	PbO	96
	Elec.—F's Law	Cu	52
	Elec.—F's Law	Ag	54
	Elec.—F's Law	Time-Amp.	94, 97
	Phys—Chem.	E.M.F.	57, 103
Li	Grav.—Sol.-Extr.	Li_2SO_4	84, 93
	Grav.—Sol-Extr	LiCl	66
	Titr.—Neutr.	Vol.	8, 40, 49, 73, 76, 89, 90, 103
Mg	Grav.—Pptn.	$Mg_2P_2O_7$	35, 40, 47, 84
Mn	Grav.—Gas-Evol.	Mn_3O_4	65
Hg	Grav.—Pptn.	HgS	3, 30
	Grav.—Pptn.	HgCl	19
	Grav.—Gas-Evol	Hg	41, 62, 74
	Grav.—Sol-Extr	Hg	11, 14, 16, 24, 26, 32, 35, 40, 42, 43, 49, 56, 60, 68, 78, 82, 93
	Titr.—Oxid-Red	Vol.	79
	Elec.—Directly	Hg	61, 99
	Phys—Chem.	Color	32
Mo	Grav.—Gas-Evol.	Mo	21
Os	Grav.—Gas-Evol.	Os	98
K	Grav.—Pptn.	K_2PtCl_6	9, 81, 83, 84, 85, 86, 87
	Grav.—Gas-Evol.	H_2	22, 26, 55
	Grav.—Sol-Extr	KCl	66, 81, 88, 96, 100
	Grav.—Sol-Extr	K_2SO_4	84, 85, 92
	Titr.—Neutr.	Vol.	2, 5, 6, 40, 42, 45, 48, 49, 55, 68, 81, 88, 89, 90, 92, 93, 100, 103
Rb	Grav.—Pptn.	Rb_2PtCl_6	85, 87
	Titr.—Neutr.	Vol.	40, 43, 89, 90, 103
Ag	Grav.—Pptn.	AgCl	61, 64, 67
	Grav.—Gas-Evol.	Ag	17, 34, 36, 38, 50, 67
Na	Grav.—Gas-Evol.	H_2	4, 22, 26, 55
	Grav.—Sol-Extr	NaCl	66, 81, 88, 96, 100
	Grav.—Sol-Extr	Na_2SO_4	82, 84, 85, 86
	Titr.—Neutr.	Vol.	1, 2, 5, 6, 27, 39, 40, 45, 46, 49, 55, 63, 68, 70, 78, 81, 88, 89, 90, 91, 93, 100, 103
Sr	Grav.—Pptn.	$SrSO_4$	82, 84, 92
	Titr.—Neutr.	Vol.	25, 89, 90, 91, 92, 103
	Titr.—Pptn.	Vol.	93
Tl	Grav.—Pptn.	TlI	18, 35

SUMMARIZED INFORMATION—Continued

Element Det'd	Method	Quantity Measured	References
	Titr.—Neutr.	Vol.*	71, 75
	Titr.—Oxid-Red	Vol.	95
	Elec.—F's Law	Time-Amp.	94
	Elec.—F's Law	Ag	71, 76
	Phys—Chem.	E.M.F.	103
Sn	Grav.—Pptn.	SnO_2	26, 30, 96, 99
	Grav.—Sol-Extr	SnO_2	34
	Elec.—F's Law	Ag	76
	Phys—Chem.	E.M.F.	103
Zn	Grav.—Pptn.	ZnO	15, 26, 40
	Extr.—Sol-Extr.	ZnO	34
	Elec.—F's Law	Ag	29
	Elec.—F's Law	Time-Amp.	94, 97
	Phys—Chem.	E.M.F.	31, 33, 57, 103
	Phys—Chem.	Density	72

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