STUDIES IN SOLVENT EXTRACTION CHEMISTRY AND ION-SELECTIVE ELECTRODES

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Papers published in the scientific literature and submitted for the Degree of Doctor of Science

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7. The Extraction of Scandium from Aqueous Sulphate Solutions by Bis(3,5,5-trimethylhexyl)ammonium Sulphate.
R.W. Cattrall and S.J.E. Slater, Inorg. Chem., 9, 598-602 (1970).

8. A Study of the Aggregation of the Sulphate and Bisulphate Salts of Bis(3,5,5-trimethylhexyl)amine in Chloroform Solution by Vapour Phase Osmometry.
R.W. Cattrall and S.J.E. Slater, J. Inorg. Nucl. Chem., 36, 841-845 (1974).

9. Atomic Absorption Determination of Yttrium in the Nitrous Oxide - Acetylene Flame.
R.W. Cattrall and S.J.E. Slater, Anal. Chim. Acta, 56, 143-146 (1971).

10. The Spectrophotometric Determination of Europium(III) Using Chrome Azurol S.
R.W. Cattrall and S.J.E. Slater, Microchem. J., 16, 602-609 (1971).

11. The Extraction of Metal Ions from Aqueous Sulphate Media by Alkylamines.
R.W. Cattrall and S.J.E. Slater, Coordination Chemistry Reviews, Vol. II, No. 3, pp. 227-245 (1973).

12. The Extraction of Sulphuric Acid with Di- and Tri(3,5,5-trimethylhexyl)amines.
R.W. Cattrall, Aust. J. Chem., 20, 2375-2370 (1967).

13. The Extraction of Sulphuric Acid by Bis(3,5,5-trimethylhexyl)amine dissolved in Chloroform.
R.W. Cattrall and S.J.E. Slater, J. Inorg. Nucl. Chem., 36, 947-949 (1974).

14. The Distribution of Sulphuric Acid between Isoamyl Alcohol and Water.
R.W. Cattrall and B.O. West, Aust. J. Chem., 19, 2385-2387 (1966).

15. The Preparation of the Phosphate Salts of 3,5,5-trimethylhexylamine and Bis(3,5,5-trimethylhexyl)amine by Solvent Extraction and the Isolation of the Complex Extracted from Aqueous Ferric Phosphate Solutions by 3,5,5-trimethylhexyl amine.
R.W. Cattrall and K.I. Peverill, J. Inorg. Nucl. Chem., 35, 2126-2127 (1973).

SECTION B: Extraction from chloride media by high molecular weight amines

16. The Rate of Mass Transfer of Metal Chlorides between Hydrochloric Acid and Alkylammonium Chloride Solutions. Part 1. Niobium(V) between 10.8 M Hydrochloric Acid and Bis(3,5,5-trimethylhexyl)-ammonium Chloride in Chloroform.
D.E. Davey, R.W. Cattrall, T.J. Cardwell and R.J. Magee, J. Inorg. Nucl. Chem., 40, 1135-1140 (1978).

17. The Rate of Mass Transfer of Metal Chlorides between Hydrochloric Acid and Alkylammonium Chloride Solutions. Part II. Niobium(V) between 10.8 M Hydrochloric Acid and Bis(3,5,5-trimethylhexyl)-ammonium Chloride in Carbon Tetrachloride.
D.E. Davey, R.W. Cattrall, T.J. Cardwell and R.J. Magee, J. Inorg. Nucl. Chem., 40, 1141-1145 (1978).

18. The Rate of Mass Transfer of Metal Chlorides between Hydrochloric Acid and Alkylammonium Chloride Solutions. Part III. Niobium(V) between 10.8 M Hydrochloric Acid and Bis(3,5,5-trimethylhexyl)-ammonium Chloride in benzene.
D.E. Davey, R.W. Cattrall, T.J. Cardwell and R.J. Magee, J. Inorg. Nucl. Chem., 41, 77-83 (1979).

19. The Mechanism of Extraction of Niobium(V) from Hydrochloric Acid by Bis(3,5,5-trimethylhexyl)ammonium Chloride Dissolved in Chloroform, Carbon Tetrachloride and Benzene.
D.E. Davey, R.W. Cattrall, T.J. Cardwell and R.J. Magee, J. Inorg. Nucl. Chem., 41, 1199-1203 (1979).

20. The Aggregation of the Chloride, Bromide, and Iodide Salts of Dilaurylamine in Chloroform.
A.T. Casey, R.W. Cattrall and D.E. Davey, J. Inorg. Nucl. Chem., 33, 535 (1971).

21. Equilibrium Constants for the Extraction of Fe(III) from 6 M Hydrochloric Acid Solutions by Tri-n-Octylammonium Chloride in Chloroform.
R.W. Cattrall and Mirna Z. Ilic, J. Inorg. Nucl. Chem., 40, 1446-1448 (1978).

22. The Extraction of Iron(III) from 6 M Hydrochloric Acid by Long Chain Amines Dissolved in Chloroform.
Mirna Z. Ilic and R.W. Cattrall, Aust. J. Chem., 37, 489-495 (1984).

23. The Mechanism of Extraction of Iron(III) from 6 M Hydrochloric Acid by Long Chain Amines in Chloroform.
Mirna Z. Ilic, R.W. Cattrall and D.E. Davey, Aust. J. Chem., 36, 1319-1326 (1983).

24. The Aggregation of Some Primary, Secondary and Tertiary Amine Hydrochloride Salts in Chloroform.
Mirna Z. Ilic and R.W. Cattrall, J. Inorg. Nucl. Chem., 43, 2855-2857 (1981).

25. The Distribution of Copper(II) between Methanolic Lithium Chloride Solutions and Benzene Solutions of Bis(3,5,5-trimethylhexyl)ammonium Chloride.
A.R. Burns and R.W. Cattrall, J. Inorg. Nucl. Chem., 35, 2489-2496

SECTION C: Extraction from chloride media by Aliquat 336

26. The Analysis of Aliquat 336® by Gas Chromatography.
Geat Lean Lee, R.W. Cattrall, Hayati Daud, I.C. Hamilton and J.F. Smith, Anal. Chim. Acta, 123, 213-220 (1981).

27. The Extraction of Mercury(II) from Hydrochloric Acid Solutions by Aliquat 336 Dissolved in Chloroform.
R.W. Cattrall and Hayati Daud, J. Inorg. Nucl. Chem., 41, 1037-1039 (1979).

28. The Extraction of Mercury(II) from Potassium Iodide Solutions and the Extraction of Copper(II), zinc(II) and cadmium(II) from Hydrochloric Acid Solutions by Aliquat 336 Dissolved in Chloroform.
Hayati Daud and R.W. Cattrall, J. Inorg. Nucl. Chem., 43, 779-785 (1981).

29. The Extraction of Cd(II) and Zn(II) from Acidified Lithium Chloride Solutions by Aliquat 336 Dissolved in Chloroform.
Hayati Daud and R.W. Cattrall, J. Inorg. Nucl. Chem., 43, 599-601 (1981).

30. The Mechanism of Extraction of Zinc(II) from Aqueous Chloride Solutions into Chloroform Solutions of Methyltrioctylammonium Chloride.
Hayati Daud and R.W. Cattrall, Aust. J. Chem., 35, 1095-1103 (1982).

31. The Extraction of Zinc(II) from Chloride Solutions by Methyltrioctylammonium and Methyltridecylammonium Chlorides Dissolved in Chloroform and Other Diluents and a Comparison with Aliquat 336.
Hayati Daud and R.W. Cattrall, Aust. J. Chem., 35, 1087-1094 (1982).

32. The Extraction of Cobalt(II) from Lithium Chloride Solutions by Aliquat 336® Dissolved in Chloroform.
Rohani Paimin and R.W. Cattrall, Aust. J. Chem., 35, 2345-2351 (1982).

33. The Extraction of Cobalt(II) from Hydrochloric Acid Solutions by Aliquat 336 Dissolved in Chloroform.
Rohani Paimin and R.W. Cattrall, Aust. J. Chem., 36, 1017-1020 (1983).

SECTION D: Extraction by high molecular weight carboxylic acids and organophosphorus compounds

34. The Extraction of Iron(III) from Nitrate Solutions by High Molecular Weight Carboxylic Acids.
R.W. Cattrall and M.J. Walsh, J. Inorg. Nucl. Chem., 36, 1643-1648 (1974).

35. The Analysis of Iron(III) using Solvent Extraction with Phenylacetic and n-Decanoic Acids.
R.W. Cattrall and M.J. Walsh, Microchem. J., 19, 123-219 (1974).

36. The Extraction of Beryllium and Aluminium from Aqueous Sulphate Solutions with Di(2-ethylhexyl)phosphoric Acid.
R.W. Cattrall, Aust. J. Chem., 14, 163-166 (1961).

37. The Recovery of Beryllia from Beryl.
R.W. Cattrall, S.A. Department of Mines, Mining Review, 110, 12-15 (1959).

38. The Extraction of Thorium from Nitrate Solutions by Dibutylbutylphosphonate.
D.C. Madigan and R.W. Cattrall, J. Inorg. Nucl. Chem., 21, 334-338 (1961).

39. The Solvent Extraction of Copper, Silver, Gold and Mercury by Some Trialkylmonothiophosphates and Trialkylphosphine Sulphides and the Attempted Use of These Reagents in Coated-Wire Ion-Selective Electrodes.
R.W. Cattrall, A.R. Martin and Sergio Tribuzio, Journal Inorg. and Nucl. Chem., 40, 687-690 (1978).

SECTION E: Ion-selective electrodes sensitive towards calcium and potassium

40. Coated-Wire Ion Selective Electrodes.

R.W. Cattrall and Henry Freiser, Anal. Chem., 43, 1905-1906 (1971).

41. Coated-Wire Ion Selective Electrodes.

H. Freiser, B.M. Kneebone, H.J. James, G.D. Carmack and R.W. Cattrall, Canadian Patent No. 950,536 (July, 1974).

British Letters Patent No. 1375785 (March 1972).

U.S. Patent No. 4,115,209 (July 1978).

Japan Patent No. 918,742 (August 1978).

West German Patent No. P22 15378 (July 1981).

42. Some Alkylphosphoric Acid Esters for Use in Coated-Wire Calcium Ion Selective Electrodes, Part I. Response Characteristics.

R.W. Cattrall, D.M. Drew and I.C. Hamilton, Anal. Chim. Acta, 76, 269-277 (1975).

43. Some Alkylphosphoric Acid Esters for Use in Coated-Wire Calcium Ion Selective Electrodes, Part II. Selectivities and Use in Potentiometric Titrations.

R.W. Cattrall and D.M. Drew, Anal. Chim. Acta, 77, 9-17 (1975).

44. Some Alkylphosphoric Acid Esters for Use in Coated-Wire Calcium Selective Electrodes, Part III. Structural Characteristics of Calcium Di(octylphenyl)phosphate.

R.W. Cattrall, M.J. Newlands and M.F. Mackay, Anal. Chim. Acta, 155, 235-242 (1983).

45. A Potassium Ion Responsive Coated-Wire Electrode Based on Valinomycin.

R.W. Cattrall, S. Tribuzio and Henry Freiser, Anal. Chem., 46, 2223-2224 (1974).

46. Serum Calcium and Potassium Analysis Using the Split Membrane Ion Selective Electrode Technique.
R.W. Cattrall and Kwok Tai Fong, Talanta, 25, 541-543 (1978).

SECTION F: Ion-selective electrodes sensitive towards anionic halometal complexes

47. A Coated-Wire Ion Selective Electrode for the Analysis of Iron(III).
R.W. Cattrall and Pui Chin-Poh, Anal. Chem., 47, 92-95 (1975).

48. Determination of Iron(III) in Mineral Samples by Titration with EDTA Using a Coated-Wire Ion Selective Electrode.
R.W. Cattrall and Chin-Poh Pui, Anal. Chim. Acta., 78, 463-465 (1975).

49. Coated-Wire Ion Selective Electrodes for the Determination of Mercury(II).
R.W. Cattrall and Chin-Poh Pui, Anal. Chem., 48, 552-556 (1976).

50. A Coated-Wire Ion Selective Electrode for the Determination of Zinc(II).
R.W. Cattrall and Chin-Poh Pui, Anal. Chim. Acta, 87, 419-427 (1976).

51. A Coated-Wire Ion Selective Electrode Responsive to Chlorocadmate(II) Ions.
R.W. Cattrall and Chin-Poh Pui, Anal. Chim. Acta, 88, 185-189 (1977).

52. A Coated-Wire Ion Selective Electrode Responsive to Chlorocuprate(II) Ions.
R.W. Cattrall and Chin-Poh Pui, Anal. Chim. Acta, 83, 355-360 (1976).

53. Ion Selective Electrodes Responsive to Chlorocobaltate(II) Ions.
Geat Lean Lee, R.W. Cattrall and I.C. Hamilton, Anal. Chim. Acta, 116, 391-396 (1980).

54. Heterogeneous Membrane, Carbon Support, and Coated-Wire Ion Selective Electrodes.
R.W. Cattrall, Ion-Selective Electrode Methodology (Ed. A.K. Covington), CRC Press, Boca Raton, Florida, 1979, pp. 131-173.

SECTION G: Papers in the general field of inorganic chemistry

55. Electron Transfer Reactions,
R.W. Cattrall, J.R. McKellar, B.O. West, Australian Atomic Energy Symp., Sydney, p. 628 (1958).

56. Low Frequency Spectra of Manganese Carbonyl Derivatives of the type $Mn(CO)_5L$.
R.W. Cattrall and R.J.H. Clark, J. Organometal. Chem., 6, 167 (1966).

57. Preparation of a New Thorium 8-Hydroxyquinolinate.
T.J. Cardwell, R.W. Cattrall, J.V. Kingston and R.J. Magee, Inorg. Nucl. Chem. Letters, 3, 491 (1967).

58. The Complex Formed between Nickel and o-Hydroxyacetophenone.
M.W. Blackmore, R.W. Cattrall and R.J. Magee, Inorg. Nucl. Chem. Letters, 4, 305 (1968).

59. The 8-Quinolinol and 2-Methyl-8-quinolinol Complexes of Manganese(III).
A.R. Burns, T.J. Cardwell and R.W. Cattrall, Aust. J. Chem., 24, 661 (1971).