RELATÓRIO DO DR. MARKO BRANICA
PERITO DA IAEA

SOBRE SEU TRABALHO JUNTO AO
INSTITUTO DE ENGENHARIA NUCLEAR

PROJETO REPROCESSAMENTO
GRUPO DE QUÍMICA NULEAR

Rio de Janeiro

De 2 de abril a 5 de setembro de 1975

BA-T-3-053
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INSTITUTO DE ENGENHARIA NUCLEAR

Dr. Marko Branica, expert of IAEA
Rio de Janeiro, September 5, 1975

Content: Report of activities of Dr. M. Branica under the IAEA Project BRA/3/04, from April 2 to September 5, 1975.

Copies: Diretoria do IEN,
Projeto de Reprocessamento,
Grupo de Química Nuclear.

The Government of Brazil requested technical assistance for the project on Nuclear Materials Analysis in order to expand the capability of the Instituto de Engenharia Nuclear (IEN), NUCLEBRÁS, in Rio de Janeiro, and the IAEA approved it under its Regular Programme for 1974, providing an expert for the services and for a duration of six months. Project BRA/3/04 (description under Encl.1).

In accordance with the Job Description and the Letter Appointment of February 25, 1975 with IAEA as short-term Technical Cooperation Expert, I carried out the mission at IEN, Rio de Janeiro, between April 2 and September 5, 1975.

Immediately after my arrival to Rio on the basis of staff, laboratory and equipment possibilities at IEN, as well as, on the discussion with Dra. Bartyra de Castro Arezzo, I proposed a working programme (Encl. 2), and it was accepted.

I was very satisfied with the collaboration conditions at IEN because during my mission a very high working enthusiasm, personal involvements and interest for the problems of application of electrochemical procedures in the characterization of nuclear materials and their analytical determination were achieved. The counterpart personnel assigned from the Nuclear Chemistry Group of the Reprocessing Project of IEN, for the work and training in the electrochemical field were:

1. Lidia Mikiko Doi, M.Sc. and Eng. in Chemistry,
   5 years laboratory experience, full time;
2. Sabine H. Strubell Fulda, M.Sc. and B. Sc. in Chemistry,
   10 years laboratory experience, part time (about 25%);

3. Horácio Vianna Oscherry, last year, Chemistry student from PUC (scholar at IEN), part time (about 40%);
4. Jorge Cabral Gaio, technician, 2 years laboratory experience, full time;
5. Flavio Nascimento dos Santos, technician, 4 years laboratory experience, part time (about 40%)

The collaboration kindly given by Dra. Bartyra de Castro Arezzo, (Chief of Nuclear Chemistry Group), as well as the support by Eng. Sergio Gorreta Mundim (Head of Projects Division), Ten. Col. Walter Cabrera da Costa (Head of Administrative Division) and by Eng. Luis Osório de Brito Aghina (Director of the IEN) to the expert's work has been essential.

The actual work performed can be summarized as follows:

1. The following instruments were installed, tested any now they are in operational conditions:

- the Sargent Fast Sweep Polarograph (Model FS-nº S-29313) provided by IAEA, and adapted for work with dropping mercury eletrode, as well as drop life timer constructed during the mission under the Project BRA/2/03 at 1972.
- the Princeton Applied Research Corp. Polarograph (Model PAR-174, Polarograph Analyzer) with corresponding X-Y plotter (Gould Brush-500).
- the Potentiostat/Galvanostat PAR Model-173 with Digital Coulometer PAR Model-179 (repaired in the Electronic Department of IEN from the shipping damage).

2. Three universal electrochemical cells of transparent polyester material have been designed by the expert and in cooperation with the workshop of IEN constructed with the following characteristics:

   Cell-1. "Cubic type", consisting of one catholytic (cubic form) and two anolytic compartments, separated by selective ion-exchange membranes of large surface (about 9 cm^2), with working volume between 60 ml and 130 ml (Figs. 1 e 2).

Cell 2. "Cylindric type 1" is water jacked termostated cell, consisting of catholytic (cylindric form) part, in which two anolytic comportaments are immersed and separated with selective ion-exchange membranes, with working volume between 100 ml and 350 ml (Fig. 3).

Cell-3. "Cylindric type 2 - small", practically of the same shape as Cell-2., but the anolytic compartments are separated only by fritted glass-disk, and with working volume between 40 ml and 100 ml (Fig. 4).

All cells are provided for work:

- under innert athosphere, with mercury cathode (which can be exchanged with rotating solid electrode),
- Pt-anodes,
- reference electrode (Ag/AgCl or Calomel electrode), with possibilities for connection for continuous flow analysis. The electrochemical analysis can be realized applying directly, into the cell, corresponding analytical electrode system. (DME, HMDE etc.)

The cells are designed for general and universal electrochemical treatment of the aqueous electrolytic solution, but it is more convenient if they are used in the specific application as follows:

Cell-1. is basicaly designed for electrochemical preparation of uranium in different oxidation state.
Provided by cationic ion exchange membranes it is possible to electrolyzed solutions of anionic uranium complexes (like carbonato-, peroxo-, phosphato-, sulphato- and other complexes) without loss of uranium from the cathodic compartment. The Cell is very convenient for direct polarographic measurements of oxido-reduction processes of uranium as well as dismutation (or recombination) of uranium (V) (V-Žutić and M.Branica, J. Polarog. Soc., 13 (1967) 9-16).
If the electrochemical compartments are separated by anionic exchange membranes the various oxidation state of uranium can be prepared, from the solutions where the uranium is in cathionic forms. This can be also applied for preparation of uranium (IV) hydroxide-sol free of other ions (M. Branica and L. Sipos, unpublished results).

Cell-2. is mostly designed for purification of supporting electrolytes. In electrolytes, the concentration of ions of many heavy metals (like: Zn, Cd, Ni, Bi, Pb, Cu, In, Tl etc...) are diminished by electro deposition into mercury cathode. To achieve the needed purity of supporting electrolytes for anodic stripping analyses (at sub-trace level) it takes more then 2 days of "non-stop" electrodeposition and keeping innert atmosphere over the solution.

Cell-3. designed mostly for potentiostatic separation of different metals for cyclotron targets (Cu, Zn; In/Cd etc...)and further development of the described procedure for determination of nuclear impurities (Cu, Pb, Bi and Cd) into uranium samples (G. W. C. Milner "The Principles and Applications of Polarography and Other Electroanalytical Processes" Longmans, Green and Co. Ltd, 4 th edition, 1966,pp.341-437).

3. The polarographic methods and techniques: the direct current (d.c.) sampled d.c. polarography, pulse and differential pulse polarography with dropping mercury eletrode (with natural and controlled drop life) were introduced.
The basic electrochemical parametra, as the rate of electrode reaction, half-wave potential, difussion current, logarithmic analysis, kinetic currents etc... of the studied oxido-reduction processes in acidic and basic supporting electrolytes (nitric acid, sulphuric/ortho-phosphoric acid, citrate, tartrate, sodium carbonate/bicarbonate and lithium hidroxide) were examined. Corresponding calibration curves for uranium and some impurities (ion, copper, lead and cadmium) by direct current and differential pulse polarographic modes of operation, were obtained. At the most favorable conditions, the uranium can be directly determined in a very wide concentration range (from $4x10^{-3}$ to $4x10^{-7}$ mol per liter of supporting electrolyte).
The analyses and mathematical treatment of polarographic curve, with special attention to separation of the overlapping d.c. polarographic waves (I. Ružić and M. Branica, J. Electroanal. Chem. 22(1969) 243; and 422) as well as criteria for recognition of the type, number of

electrons involved and reversibility of the electrode reaction (I.Ružić A. Barić, and M. Branica, J. Electroanal. Chem., 29(1971) 411) were demonstrated on the actual obtained polarograms.

4. A development of a new electroanalytical procedure for simultaneous determination of the uranium (VI) and tri-butyl-phosphate (TBP) concentration in the aqueous solutions of nitric acid, after extraction with organic solvents starts wiht very promissing results.
In nitric acid the polarographic current depends on the concentration and the ratio of both components. At the concentration under 10^{-4} M of uranium (VI) the TBP increase the d.c. and d.p. currents, in the medium range (from 10^{-4} M to 10^{-3} M UO_2^{+2}) no influence is observed, and at the higher concentration of uranium the inhibition effect is noticed, and it is in agreement with already published results (D. Krznarić, B. Ćosović and M. Branica, J. Electroanal. Chem., 33(1971) 61-68).
In supporting electrolyte composed by lithium hydroxide (or carbonate) only uranium (VI) gives one-electron polarographic wave at about - 1.0 V.vs. S. C. E (V, Žutić and M. Branica, j: Electroanal. Chem.,28(1970) 187 - 195), and the current is not essentially influenced by TBP.
It seems - from these preliminary results - that the simultaneous determination of uranium and TBP can be achieved:

- or by the plotting of direct current (d.c.) and diferential pulse (d.p.) polarographic curves, at the two dilution level of the same sample,
- or by applying two different supporting electrolytes, i.e. nitric acid and lithium hydroxide/carbonate.

The additional polarographic measurements, as well as results on the nature of the electrode reaction, by other electroanalytical techniques (i.e. Kalousek Commutator and/or multistep potentiostatic chronocoulometry) will be of great help for finalization of this work.

5. The potentiostatic coulometry, using the mentioned cells (see 2.2.), were applied for electrolysis of uranium (VI), (V) and (IV) in sodium carbonate/bicarbonate (V. Pravdić, M. Branica and Z. Pučar, Electrochem. Technology, 1 (1963) 312-325), and perchloric acid solutions

(L. Sipos, Lj. Jeftić, M. Branica and Z. Galus, J. Electroanal. Chem. 32 (1971) 35-47).
Investigation on same interactions of different oxidation state of uranium (disproportionation-recombination) are introduced, and the concentration of the each oxidation state of uranium are polarographicaly followed. The corresponding kinetics parametra are evaluated (M. Branica and V. Pravdić, "Polarography 1964", Procs. Int. Polarographic Congress-Southampton, 1964, MacMillan, London 1966, pp. 435-445).

6. The spectrophotometric study on the interactions of uranium (IV), (electrochemicaly prepared) with different agents (perchloric and nitric acid, sodium perchlorate and nitrate, and hydrazine) into aqueous solution gives very interesting preliminary results from the point of view of the reproducibility of spectra and the mechanism of corresponding U(IV) hidrolization and complexation processes during reprocessing of the spent nuclear fuels.

7. The preliminary investigation on the electrodeposition of metal ions from the uranium suphate solution into mercury cathode, for the polarographic determination of nuclear impurities (Furman et al.J.Washington Academy Sc., 38, nº 5 May, 1948) are started.
To avoid distillation of mercury, originaly proposed, the investigation on the possibility for direct determination of metals concentration into amalgam by differential pulse/anodic/polarography, as well as the determination of metal ions concentration after reoxidation of amalgams into appropriate supporting electrolyte are also started. The alternation now seems possible, because of more higher sensitivity of a new developed differential pulse polarography.
The details of obtained results can be seen from the corresponding "Nota Técnica" which will be written M. Sc.L.M. Doi, M.Sc.S.H.S.Fulda and H. Oschery.
During the mission in addition to "every day" training and discussions, I give the following public lectures:

- "Human Activities and the Nature of Seawater"
  (Institute for Radiation Protection and Dosimetry, Rio de Janeiro, April 30, 1975).

- "Speciation of Stable and Radioactive Trace Metals in Aquatic System" (Institute for Radiation Protection and Dosimetry, Rio de Janeiro, May 14, 1975).
- "The Application of Electrochemical Process in Uranium Technology" (IEN, Rio de Janeiro, August 26, 1975).

Short Comments and Recomendations

Even one can conclude, from the actual work performed, that this mission was succesful, but the working programme, proposed by the expert, was not completed in all details.

The main reasons can be summarized as follows:

- the duration of the mission (6 month) was too short to fullfill the very broad proposed programme,
- in the training, the direct continuation of the Project BRA/2/03 was missed, because another counter-part personnel were assingned for the Project BRA/3/04 (due to the reorganization at IEN),
- lack of the additional accessories (as hanging mercury drop eletrodes plug - in units for oscilloscope, electrochemical cells, electrodes and electrical - peristaltic pumps etc...).
- problems concerning to the grounding of instruments and mechanical shaking of the laboratory by air-conditioner,
- time consuming process for purchasing chemicals and other materials for laboratory work and/or not enough large "stock" of these materials at IEN,
- lack of current literature on electrochemistry (Journals, new monographs, proceedings and bibliography).

At the same time its very important to notice that the laboratory working conditions at IEN (and specially in the Nuclear Chemistry Group) have been essentialy improved during the last three years, because of more experienced staff, additional laboratory facilities with new equipment available.

I propose,that further development in electrochemistry can be achived at IEN by working on the programme as follows:

1. Aplication of electrochemical processes in uranium technology

A. Research and development of new physico-chemical separation procedures for hydrometalurgical production of uranium from new material and/or spent nuclear fuel elements based on electrochemical procedure.

At the first phase a "bench scale" separation processes have to be developed from the micro-scale laboratory experiments taking into account the parametra for further scale-up step.

The broadening of the electrochemical studies can be based on the following publication:

M. Branica, V. Pravdić and Z. Pũcar, Croat. Chem. Acta, 35(1963) 281,

M. Branica and V. Pravdić in "Polarography 1964" ed., G.J. Hills, MacMillan, London, 1966, pp. 435-445.

V. Pravdić, M. Branica and Z. Pũcar, Procs. 3 rd Int. Conf. Peaceful Uses At. Energy, Geneva 1964 Vol. 28, 1-14 (P/703),

L. Sipos, Lj. Jeftić, M. Branica and Z. Galus, J. Electroanal. Chem., 32 (1971) 35-47,

V. Žutić and M. Branica, J. Electroanal. Chem., 52 (1974) 217,

Anonimus, Chem. Eng. News, Nov. 11, (1974) 13 and Michael K. McAbee, Chem. Eng. News, Dec. 2, (1974) 18-19

H. Schmieder, F. Baumgärtner, H. Goldacher, H. Hansbenger, KFK 2003/ PWA 3 1975,

as well as by cooperation with the working groups on the pilot-plant scale in:

Institut fUr Heisse Chemie, Gesellschaft fUr ernforschung m.b.H., Karlsruhe, F.R. Germany and/or
"Ruder Bõsković" Institute, Zagreb, Yugoslavia.

Successfull cooperation can result in the development of a new procedures in the uranium hydrometalurgy based on the electrochemical way of exchange of oxidation state of uranium, and accompained

elements (plutonium, nuclear impurities, fission products etc...) It can be applied into:

- Separation of uranium from raw material by specific electrochemical reduction of uranium (VI) to (IV) (in sodium-ammonium carbonate and/or sulfuric acid solutions). The U(IV) can be separated from solution as UO_2 or UF_4 precipitate;

- Reprocessing of spent nuclear fuel material by consecutive electrochemical changes between uranium (VI)-(VI)-(VI) states and corresponding state of plutonium (IV) and (III), and/or development of a new procedure based on electrochemical solubility properties of uranium peroxo-carbonato complexes;

- Preparation of nuclear pure and physico-chemical defined uranium compounds in the forms of:

  a) uranium dioxide powder ceramic grade, and/or for preparation of U-metal of UF_4,

  b) uranium dioxide micro spheres (by electrochemical-sol-gel treatment) and,

  c) uranium tetrafluoride and/or double salt with ammonium fluoride.

B. Electrochemical analyses and characterization of nuclear materials can be applied directly into physico-chemical separation studies, as well as the procedures for the control of quality of basic nuclear material obtained by other technological way. At high concentration range for determination of oxidation state of uranium, plutonium and neptunium the spectrophotometric techniques will be very usefull, also.

2. Application of electrochemical separation processes in production of carrier-free radio nuclides.

The potentiostatic electrolysis can be successfully applied, for the separation of metals of cyclotronic target, also, carrier-free radionuclides can be separated by the elimination of one component into mercuric eletrode, while the other is keeped into electrolytic solution. By this way it is possible to separate Cu/Zn, In/Cd etc...

The fulfillment of the programme mentioned above should be organized as follows:

Expert Missions:

1. An expert for the electrochemical determination of nuclear impurities in uranium compounds by application on voltametry and corresponding electro-analytical techniques, for a period of 6 months in 1976

2. An expert in the field of the physico-chemical separation of uranium for a 12-18 months period toward the begining of 1977.

Fellowships:

1. Dra. Bartyra de Castro Arezzo, for complection of the manuscript on the development of a new analytical method for simultaneous determination of U(VI) and TBP in nitric acid - two weeks at the "Ruder Boškovič" Institute, Zagreb, Yugoslavia.

2. International Fellowship should be awarded in the field of electrochemical instrumentation, for a 3 months period to ward the beginning of 1976, for the development of a new electroanalytical method for simultaneous determination of uranium (VI).

3. Fellowship during one year (from the middle of 1976) for training in electroanalytical technique applied in nuclear technology.
   - possible places: KFA, Inst, for Analyt. Chem., JUlich, Germany, and/or "Rudjer Boskovič" Institut, Zagreb, Yugoslavia.

4. A fellowship during 2-3 years (from Sept. 176) with education and research work leading to Ph.D. in general electrochemistry. Proposed places, Department of Chemistry at the following Universities:

   Ottawa University, Ottawa, Canada, Lab. of Prof. Brian Conway, New York State Univ., Buffalo, N.Y., USA, Lab. of Prof.Stanley Bruckenstein, Colorado State Univ., Fort Collins, Lab. of Prof. Robert Osteryoung, and Bristol University, Bristol, G.Britain, Lab.Prof. Roger Parsons.

5. An international fellowship during one year (10-12 months, at 1977/78) for training in the field of nuclear technology applying electrochemical processes for preparation of UO_2- powder or small spherical particles (sol-gel electrochemical process)

   - possible place "Rudjer Bošković" Institut, Zagreb, Yugoslavia.

Additional Equipment Required:	Cost estimate in US$
1. Electrochemical acessories for enlargement and to complete the existing instruments at IEN (available, from the Princenton Applied Research Corp.,P.O.Pox 2565,Princenton, N.Y.08540 USA)	
A. Hanging Mercury Drop Electrodes, Magnetic Stirrer, Polarography Stand, Electrolyte Purification apparatus, Glassy Carbone Eletrode, Anodic Stripping voltammetry Complet	1,700
B. PAR-173/42; PAR-315 and 314	2,600

C.	Corresponding plug-in units for Tectronix M-7603 Osciloscope		900
D.	X_1 , X_2 - Time Recorder		1,800
		Sub total	7,000 US$
2.	ICEP - M.2 - (without recorder)		3,500
3.	Complex electrochemical system (PAR-170)		15,000
4.	Pumping system with the control of flow rate (peristaltic pumps)		1,600
5.	Universal autoanalyzer system (sample changer, proportional pump, diff. reactors, desgassing system-without finale colorimetric determination) - Technicon		8,500
6.	Double beam UV-visible Spectrophotometer (CARRY M-XVII) with thermostated water-jacked house and flow-in-out cells, and corresponding accessories	Beckman - M6000	24,000
7.	Universal chemical reactors (with working volumes of 5 and 20 liters)		2,600
8.	Thermostat-cryostat (for work between -10°C and +90°C)		1,000
		Total	63,200

Additional literature is also required (Encl. 3)

Dr. Marko Branica
expert of IAEA at IEN
Rio de Janeiro.

MB/ia.

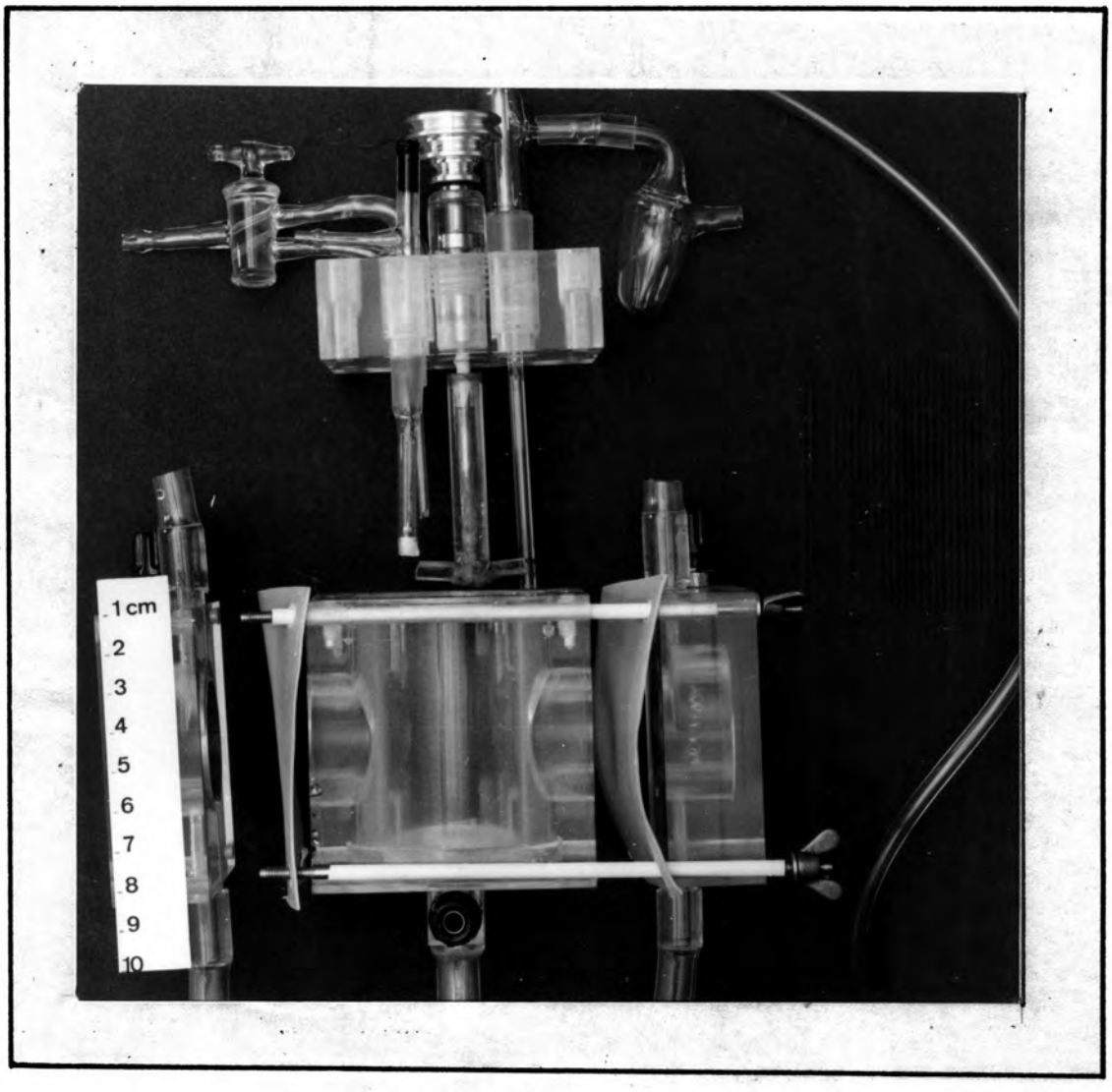

Fig. "1" - "CUBIC TYPE" - CELL

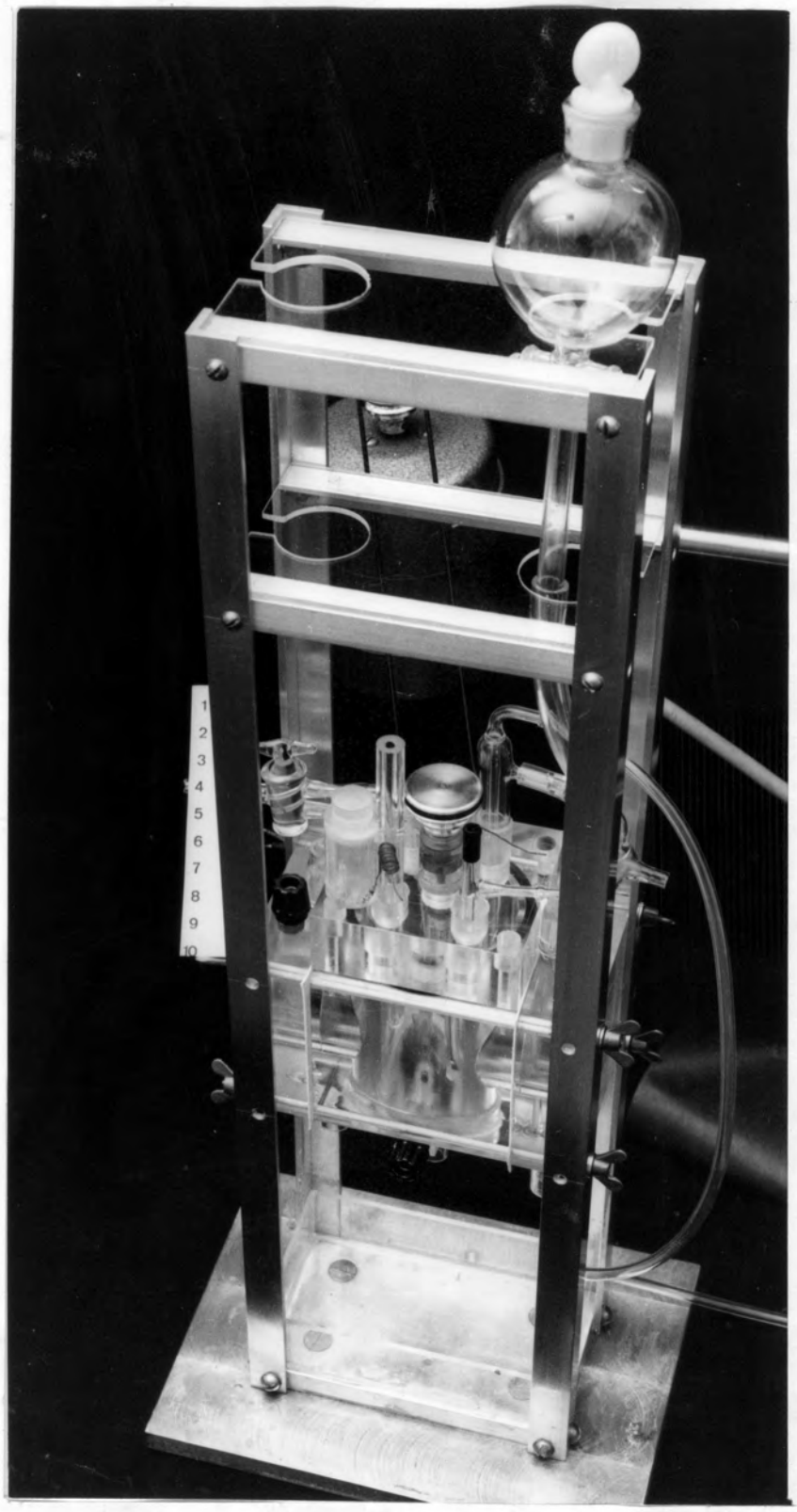

Fig. "2" - "CUBIC TYPE" - CELL

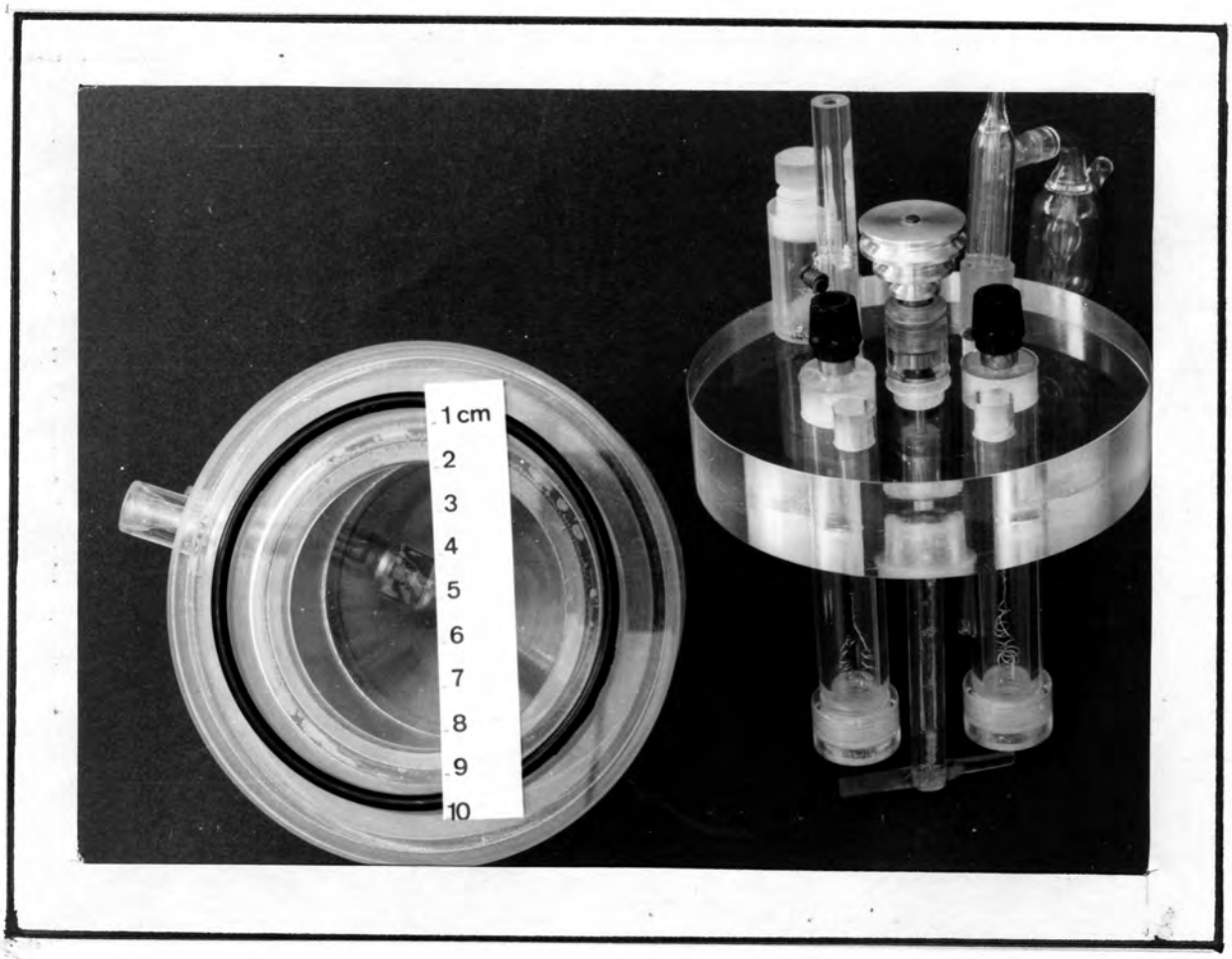

Fig. "3" - "CYLINDRIC TYPE 1" - CELL

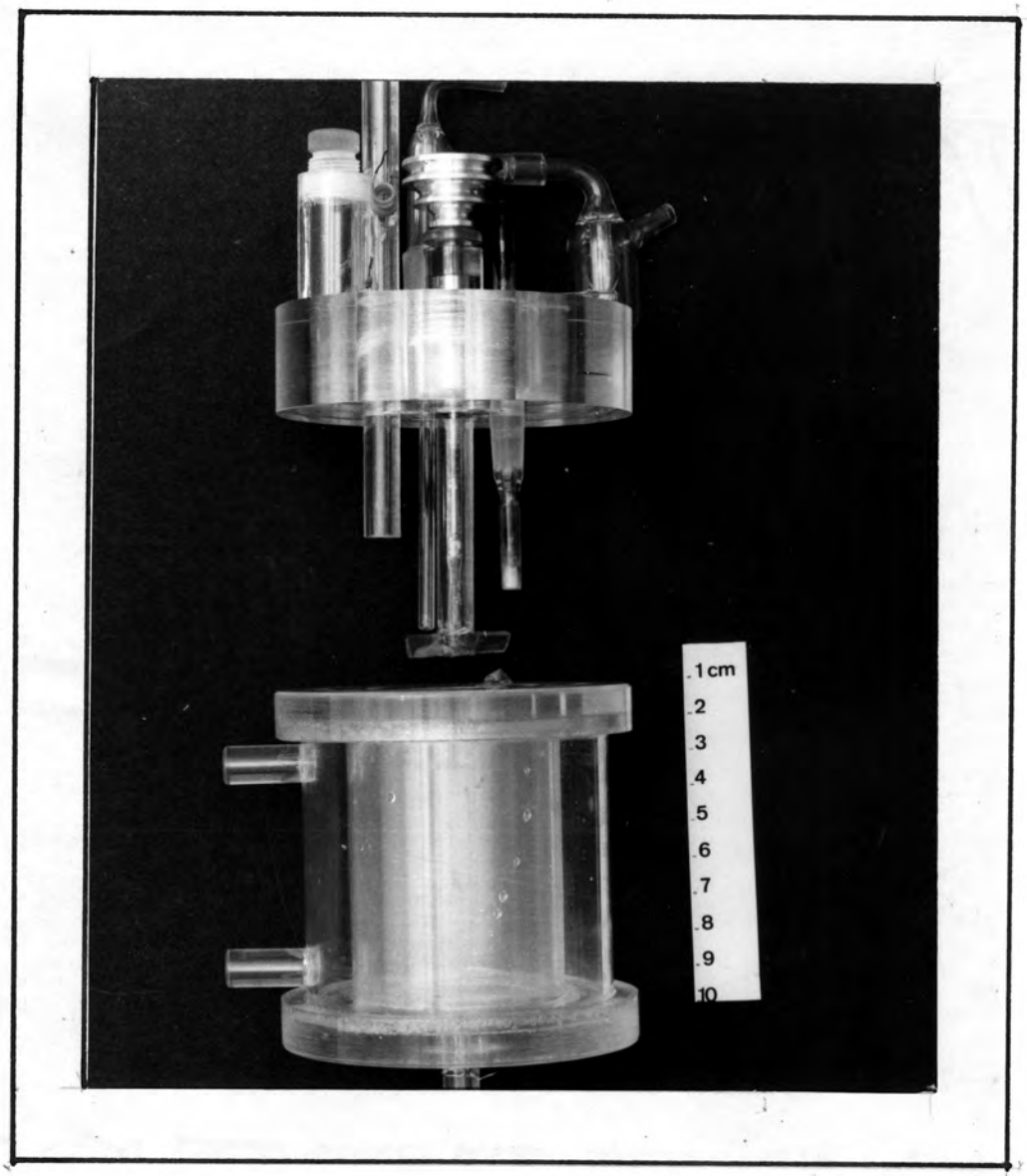

Fig. "4" - "CYLINDRIC TYPE 2" - CELL

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RP 1974

INTERNATIONAL ATOMIC ENERGY AGENCY
REQUEST FROM THE GOVERNMENT OF BRAZIL
JOB DESCRIPTION JADA BRA/3/04

Special field:	Nuclear Materials Analysis (Polarographic and other electro-chemical techniques)
Duty Station:	Institute of Nuclear Engineering (IEN), Rio de Janeiro
Duration:	6 months
When required:	As soon as possible
Duties:	To train the staff at IEN in the analytical application of polarography to nuclear materials, and also to introduce such processes as potentiostatic electrolyses and voltametry. Particular interests are in the following: 1) electroanalytical methods for the determination of uranium concentration, uranium oxidation states, and corresponding impurities in aqueous solutions; 2) quality control of the basic nuclear materials; and 3) uranium (and thorium) separation processes based on electrochemical procedures.
Qualifications:	Senior level scientist with experience in the aforementioned.
Language:	English
Background information:	This project is a follow-up to assistance provided by the Agency to IEN under its regular programme for 1970. The immediate aim is to assist the Reprocessing Group at IEN which is presently organizing hot analytical laboratories as part of the programme on reactor fuel elements adopted by the Brazilian Nuclear Technology Company (CBTN). Laboratory scale experience with the PUREX process is to be developed under this programme. The Institute has basic laboratories, which are well equipped for the work involved. Specifically, there is a polarograph and several polarographic cells. Three chemical engineers and two chemists are working on the project to which two technicians are also assigned.
Date of issue:	15 November 1973

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PROPOSED WORKING PROGRAMME FOR GROUP OF NUCLEARCHEMISTRY AT IEN
(Rio de Janeiro, May, 1975)

For the training of the staff in IEN in the application of polarography and related electrochemical techniques for characterization of nuclear materials, the expert's plan for the future activities can be summarized as follows:

1. Electroanalytical methods for determination of:

a) uranium concentration in:
- acidic solutions (nitric, sulphuric/phosphoric, hydrochloric, citric, and other acids)
- alkaline solutions (ammonium and sodium carbonate, lithium hydroxide and other)

with correspondig studies of the influence and interferences of present organics (like TBP and SAS) and inorganics (like Fe, Al, Cu and other) on reversibility of electrode reactions, reproducibility of results and sensitivity limits.

b) uranium oxidation state
- in aqeous solution (carbonate, and lithium alkaline sol., and mixture of sulphuric and phosphoric acids)
- in uranium oxides samples (after dissolution in acids)

c) nuclear impurities in uranium compunds by:
- direct determination (after dissolution of compunds in selected supporting electrolytes)
- indirect determination (after separation processes)

2. Quality control of basic nuclear material by determination of

a) uranium concentration and oxidation state in different material, and after various separation processes,

b) accompained trace elements with uranium as Cd, Pb, Cu and other,

3. Physico-Chemical Separation processes of uranium (plutonium and thorium) based on electrochemical procedures:

a) Potentiostatic electrolysis of uranium to appropriate oxidation state in aqueous solution:
- alkaline, containing: ammonium and sodium carbonate, and/or hydrogen peroxide, lithium hydrioxide;
- acidic, containing: hydrochloric, hydrofluoric, sulphuric and other aci

b) Dtermination of some separation factors in dependence of uranium oxidation state at the starting aqueous phase by:
- precipitation,
- coprecipitation,
- extraction (liquid-liquid), and
ion exchange procedure

c) Determination of oxidation state of some nuclear impurities and/ r of some fission products in relations with the different oxidation state of uranium in the same solution.

The proposed working programme is taking very broad, and it is impossible to be realized during next 4 month, but it can be applied as a general frame and goals for the future activities of research group devoted to electrochemistry in IEN. It can be also used as a stimulator for the counterpart personnel to achieved it after the period of the ex-

BA.T.2033
Encl."3"

List of electrochemical literature

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   Wiley - Interscience, 1970

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8. P. ZUMAN, I.M. KOLTHOFF, "Progress in Polarography", Vol. 1 and 2
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2. Electrochimica Acta, Pegamon Press, Oxford-London-New York, Paris PO Box.

3. Journal of Electrochemical Society, Editorial Office PO Box 2071, Princenton, N.J. 08540, USA.

4. Elektrohimiya, Izdat. "Nauka", Moskva, Adres redakcii 117071

Encl. 1

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RP 1974

INTERNATIONAL ATOMIC ENERGY AGENCY
REQUEST FROM THE GOVERNMENT OF BRAZIL
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Date of issue:	15 November 1973

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Encl. 2 3A.T.3.013 12 pgs

Dr Marko Branica (IAEA-Project BRA/3/04)

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(Rio de Janeiro, May, 1975)

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-alkaline, containing: ammonium and sodium carbonate, and/or hydrogen peroxide, lithium hydrioxide;
-acidic, containing: hydrochloric, hydrofluoric, sulphuric and other a

b) Dtermination of some separation factors in dependence of uranium oxidation state at the starting aqueous phase by:
- precipitation,
-coprecipitation,
-extraction (liquid-liquid), and
ion exchange procedure

c) Determination of oxidation state of some nuclear impurities and/or of some fission products in relations with the different oxidation state uranium in the same solution.

The proposed working programme is taking very broad, and it is impossible to be realized during next 4 month, but it can be applied as a general frame and goals for the future activities of research group devoted to electrochemistry in IEN. It can be also used as a stimulator for the counterpart personnel to achieved it after the period of the expert work in IEN.

Encl. 3

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