Attachment 12

BIAPWS Report to IAPWS for 2003

BIAPWS has continued its programme of providing co-ordination of information to the sponsor companies. This year an expanded format consisting of a symposium with associated workshops was introduced. This event took place in May 2003. The programme was as set out in Attachment A to Attachment 12. Although support was less strong than in previous years, BIAPWS has made the commitment to continue to support such events on a regular basis.

Where possible BIAPWS is encouraging the publication of the material presented at its symposia in PowerPlant Chemistry.

The BIAPWS Prize

BIAPWS has also introduced a prize for the best University undergraduate project in fields of relevance to IAPWS interests. The Prize of £1000 has just been awarded to Miss Lindsay Plant from the University of Manchester for a research project report entitled "Third Phase Formation in the Purex Process".

BIAPWS Sponsors

Support for BIAPWS activities has proved more difficult to sustain during the last year because of economic pressures on the sponsor companies.

Despite these pressures , BIAPWS retains the active support of the following companies: *ABB Automation, Alstom Power, British Energy, ESB, Innogy, Powergen, PX Limited and Scottish Power*

G J Bignold
23 August 2003

Attachment A to Attachment 12

Workshop 1 – 6 May 2003

Use of Alternative Boiler Water and Feedwater Treatment Chemicals
- Facilitator - Richard Harries, Powergen
Steam Purity requirements for Unit Start-up
- Facilitator – Mr. Ken McGrath

Wednesday 7 May

Symposium on Power Plant Chemistry and Corrosion Issues

Session 1 ***- Chemistry and materials issues for steam/water circuits***
Avedøre 2 – a Multi-fuel Concept. – J. P. Jensen, Energi E2, Denmark.
Environmental cracking processes in power plant materials: Electrochemical Interactions – J. D. Atkinson, Sheffield Hallam University, U.K.
Fundamental aspects of oxidation processes for engineering materials in steam. – S. Osgerby , NPL, UK.
Corrosion of stainless steels – Interaction with Carbon Dioxide. E. Maughan - College of Knowledge, and J. Rau. Dockweiler, Germany.
Session 2 ***Corrosion Issues in Steam Water Circuits***
Long time stress corrosion testing of steam turbine rotor and disc steels – S. R. Holdsworth and B. W. Roberts - Alstom Power Ltd, U.K.
Electrochemical Corrosion Monitoring in a Low Pressure Steam Turbine – G. Quirk, British Energy , U.K
Interpretation of Corrosion Monitoring Data in terms of Steam Turbine Operation – G. Bignold, Innogy, U.K.

Workshop 2 - Thursday 8 May

Power Cycle Chemical Control - Facilitator – Patrick Colman, ESB
Materials Selection issues and implications for Power Plant Chemistry - Facilitator – Geoff Bignold, Innogy

Attachment 13

The Czech National Committee

International Association for the Properties of Water and Steam

REPORT on IAPWS related activities – July 2002 / August 2003

Submitted to the EC Meeting of IAPWS, Vejle – August 2003.

National Committee Contacts:

CZ NC PWS - Institute of Thermomechasnics, Dolejskova 5, 182 00 Prague 8, Czech Republic

Fax: + 420 2 858 4695, E-mails: sifner@it.cas.cz; secr.czncpws@it.cas.cz

Prof. R.Mareš, Fax: + 420 377 638 102, E-mail: maresr@kke.zcu.cz

Following Institutions participated in the research into the thermophysical properties and chemical processes:

Institute of Thermomechanics (IT) AS CR, Department of Thermodynamics, Dolejskova 5, CZ-182 00 Prague 8

Czech Technical University in Prague (CTU), Faculty of Mechanical Engineering, Department of Fluid Mechanics and Power Engineering, Technická 4, CZ-166 07 Prague 6

Technical University Brno (TU), Faculty of Mechanical Engineering, Department of Thermomechanics and Nuclear Energetics, Technická 2, CZ-616 69 Brno

Institute of Chemical Technology Prague (ICT), Power Engineering Department (ICHT-IE) and Department of Physical Chemistry (ICHT-IPCh) , Technická 5, CZ-166 28 Prague 6

University of West Bohemia (UWB), Faculty of Mechanical Engineering, Department of Power System Engineering, Univerzitní 8, CZ-306 14 Plzen

SKODA ENERGO, Turbines, Plzeň, Inc., Tylova 57, CZ-316 00 Plzen

Nuclear Research Institute plc. (NRI), Rez, CZ-250 68 Rez

Technical University of Liberec (TUL), Department of Chemistry, CZ-461 19 Liberec.

Activities were sponsored by the Grant Agency of the Academy of Sciences and Grant Agency of the Czech Republic, SKODA ENERGO-Turbines, Plzen Inc., Ministry of Education, Youth and Physical Training, Ministry of Industry and Trade, and IAPWS.

- Prof.Mares (UWB) and Dr.Sifner (IT) prepared a paper on temperature conversion and recalculation of the thermal conductivity Ref. [1].
- Prof.Mares (UWB) solved a problem of measurements of heat when the supplying medium is wet steam and presented at the Conference Power Engineering-2003 organized by University of West Bohemia, Ref. [2].
- Prof.Marsik (IT) with co-authors modified and finished the manuscript of the Chapter 7: Binary Homogeneous Nucleation in Selected Aqueous Solutions for the ATLAS, Ref. [3]. The modifications respected recommendations of Dr.Palmer, Dr.Harvey, and reviewers.
  The further results of investigations into condensation, evaporation, and cavitation are presented in Refs. [4 to 9].
- Doc. Sedlbauer (TUL) collaborated with Profs. Majer and Wood on preparing the final version of Chapter 4: Calculation of Standard Thermodynamic Properties of Aqueous Solutes in a Wide Range of Temperatures and Pressures for the ATLAS Ref. [10]. In further research the

group (CZ-Fr cooperation) developed and applied the contribution method for standard thermo-dynamic properties (namely air-water distribution constants) of hydrocarbons in a wide range of temperature and pressure Refs. [11 to 15].

- Research activities at the CTU in Prague, Dept. of Fluid Dynamics and Power Engineering headed by Prof. Petr have continued during the period 7/2002 – 8/2003 in further improving our knowledge on the droplet nucleation process occurring in LP steam turbines by means of
    - analysis of realised diagnostics of wet steam in 1000 MW nuclear and 210 MW fossil steam turbines
    - tests with the expansion chamber for controlled heterogeneous droplet nucleation of steam.

The diagnostics of wet steam at the exit of L-0 turbine stage (from the root to the blade tip) consisted in prediction of

- droplet size spectra and moisture level
- electrostatic charge of the droplet population
- chemical impurities in the steam.

The expansion chamber was found to be suitable test equipment for prediction of still unknown initial size and concentration of the heterogeneous impurities that could participate in the nucleation process. The data obtained in the mentioned turbine and the expansion chamber tests have been used in improving computational model of the droplet nucleation in LP steam turbines. Information on the research activities can be found in Refs. [16, 17].

- ICT-IE is concerned with power cycle chemistry, which is divided into water treatment for fossil and nuclear power plants, problems of electrochemistry and questions of material and corrosion. Typical behavior of organic compounds in steam/water cycle is studied. The results of this research team are published in Refs. [18 to 28]
    - ICT-IE organized "The 4th International Power Cycle Chemistry Conference" (CHEOS 4) in September 3-5, 2002 in Prague under the auspices of the CZ NC PWS.
- Dr.Hnedkovsky (ICT-IPC) with collaborators investigated properties of organic solutes in water. The solute vapor absorption technique was applied at measurement of aqueous solubility of hydrophobic volatile organic compounds. Solution and transfer processes were modelled in non-polar solutes in water and aqueous solutions. Published articles are under Refs. [29 to 38].
- Stastny (SKODA ENERGO) with co-workers studied effects of deposits on the blades of HP and MP parts of steam turbine in fossil power station by chemical analysis, investigated degradation of steam turbine blade surfaces by deposits of chemicals, tested numerical models of the water steam flow with condensation in nozzles, and developed an advanced numerical model with entropy calculation. Refs. [39 to 43].

Reactor services division of Nuclear Research Institute Řež plc. has been engaged mainly in loop experiments and material testing in the research reactor LVR-15. Investigation of an effect of simultaneous influence of irradiation, water chemistry and high parameters (pressure, temperature) on behaviour of nuclear power plants structural materials and components is the main goal of the experimental programmes. The irradiation projects in progress are focused currently on the following research areas:

- investigation of fuel rod cladding materials (eg. Zircaloy-4 alloy) corrosion behaviour at specific VVER water chemistry conditions,
- investigation of an effect of water chemistry on radionuclides transport and radioactivity build-up in the reactor primary systems (eg. effect of ammonia and hydrazine),

- investigation of an effect of water chemistry, stress level and irradiation on irradiation assisted stress corrosion cracking (IASCC) of reactor pressure vessel and in-core structures materials.

A significant share of their effort was devoted to co-operation with nuclear power plants (NPPs), mainly in field of water chemistry, corrosion problems and radiation control. The following activities were carried out:

- A passivation procedure of the primary system inner surfaces during hot functional tests was developed and applied at unit 1 and 2 of NPP Temelín. Surveillance samples (coupons) were placed into the primary circuits and subsequently analysed to obtain information about characteristics of the developed passive film (morphology, chemical and phase composition).
- Primary and secondary water chemistry guidelines for VVER-440 and VVER-1000 units was prepared and issued for NPPs operated by the Czech Utilities (CEZ a.s.). Main principles of the guidelines reflect current status of knowledge and operational experience obtained in NPPs.

Young Scientists IAPWS Fellowships:

EC IAPWS granted a fellowship to T. Němec on the basis of the Proposal for the Young Scientists IAPWS (CZ-US) Project “Thermodynamic of Binary Homogeneous Nucleation in Superheated Steam”. The scientific cooperation proceeds under supervising Prof.Maršík, Dr.Hrubý (both Czech Republic) and Dr.Palmer and Dr.Simonson (both U.S.A). The subject of the project consists in preparation a database of nucleation-relevant thermodynamic properties for several water-admixture binaries relevant to power cycles and to employ this database in a nucleation simulation program, solving the kinetic equations of nucleation. Final report of the project will be submitted by the end of 2003, brief information will be given at the WG-PCSA meeting in Denmark.

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Attachment 14

Danish National IAPWS Committee - DIAPWS

c/o IDA, Kalvebod Brygge 31 - 33, 1780 Copenhagen V

20 February 2003

IAPWS REPORT 2002

The research activities in 2002 in Denmark in the field of properties of water and steam were mainly concentrated on continuation of activities started in the previous year. Due to the difficult economic situation new research has not been initiated.

Part of the investigation of solubility of salts in superheated steam finished in 1999 were published in Power Plant Chemistry.

Mathematical modelling of thermodynamic properties of ammonia / water mixtures is in progress at the Technical University of Denmark, Copenhagen. The model takes the chemical interaction between ammonia and water into account, which improves its fit to the experimental data.

Measurements and modelling of density and viscosity of multicomponent aqueous electrolyte solutions is in progress at the Technical University of Denmark, Copenhagen.
The aim is to predict the scaling in hydrogeological systems.

Modeling of multicomponent aqueous electrolyte system and application of models to the recycling process for fertilizer from ash residues is in progress at the Technical University of Denmark, Copenhagen.

Publications in 2002:

J.P.Jensen, K.Daucik; Solubility of Sodium Chloride in Superheated Steam, Power Plant Chemistry 4 (2202), No. 11, p. 653 - 659
J.P.Jensen, K.Daucik; Solubility of Sodium Sulfate and Sodium Hydroxide in Superheated Steam, Power Plant Chemistry 4 (2202), No. 12, p. 735 – 740

Attachment 15

Research Activities on the Thermodynamic Properties of Water Substance in Germany 2002/2003

In the period named above the following work has been done:

University of Applied Sciences of Zittau and Görlitz

Prof. Dr.-Ing. habil. H.-J. Kretzschmar

1. Supplementary backward equations $T(p,h)$, $v(p,h)$, and $T(p,s)$, $v(p,s)$ for region 3 of IAPWS-IF97

- The backward equations $T(p,h)$, $v(p,h)$, and $T(p,s)$, $v(p,s)$ for region 3 of IAPWS-IF97 were successfully evaluated by IAPWS. During the evaluation process, further comparison and test calculations were carried out.
- The Draft of "Supplementary Release on Backward Equations for the Functions $T(p,h)$, $v(p,h)$, and $T(p,s)$, $v(p,s)$ for region 3 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam" was completed

2. Supplementary backward equations $p(h,s)$ for region 3 of IAPWS-IF97
   - The backward equations $p(h,s)$ for region 3 were completed and successfully tested in process modelling.
   - In addition, equations of h and s for the region boundaries and an equation $T_{sat}(h,s)$ for wet steam were developed. The equations can be used in combination with the Industrial Formulation IAPWS-IF97.
   - The Draft of "Supplementary Release on Backward Equations $p(h,s)$ for Region 3, Equations as a Function of h and s for the Region Boundaries, and an Equation $T_{sat}(h,s)$ for Wet Steam of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam" was formulated and submitted to the IAPWS Working Groups "Industrial Requirements and Solutions" and "Thermophysical Properties of Water and Steam"

3. Supplementary backward equations $v(p,T)$ for region 3 of IAPWS-IF97
   - The investigations regarding the achievable accuracy close to the critical point and the division of region 3 into subregions were completed.
   - First equations were developed for the subregions.

4. Supplementary backward equations $p(h,s)$ for regions 1 and 2 of IAPWS-IF97

- The comprehensive publication:
  Kretzschmar, H.-J., Cooper, J. R., Dittmann, A., Friend, D. G., Harvey, A., Gallagher, J., Knobloch, K., Mareš, R., Miyagawa, K., Stöcker, I., Trübenbach, J., Wagner, W., and Willkommen, Th., "Supplementary Backward Equations for Pressure as a Function of Enthalpy and Entropy $p(h,s)$ to the Industrial Formulation IAPWS-IF97 for Water and Steam"
  was completed and submitted to the Journal of Engineering for Gas Turbines and Power.

5. Investigations on Thermodynamic Properties of Humid Air - Part of the project "Advanced Adiabatic Compressed Air Energy Storage" (AA-CAES) of the European Union

- A property data base for humid air was set up
- Comparison calculations of different models for calculating thermodynamic properties of humid air were started

6. Implementation of the Industrial Formulation IAPWS-IF97 on pocket calculators

- The program FluidCASIO for Casio ALGEBRA 2.0 was completed.
- The program FluidTI for the model voyage 200 of Texas Instruments was prepared.

7. Property libraries for water and steam, combustion gas mixtures, and humid air for education

- The versions for students of the programs
  - Add-In FluidEXL for Excel®
  - FluidMAT for Mathcad®

  were revised.

Ruhr-Universität Bochum

Prof. Dr.-Ing. W. Wagner

1. Uncertainties in Enthalpy for the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (IAPWS-95) and the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF97).
   These investigations resulted in the IAPWS Advisory Note No. 1 that is ready to be adopted by IAPWS at its annual meeting in Vejle, Denmark, 2003.

Attachment 16

The Hellenic National Committee
International Association for the Properties of Water and Steam

REPORT on IAPWS related activities

Submitted to the EC Meeting of IAPWS, Vejle - August 2003

National Committee Contact:
Prof. Marc J. Assael, Chemical Engineering Department, Aristotle University
54124 Thessaloniki, Greece
Tel. +302310.996163, Fax. +30231.996190, EMail. assael@auth.gr

SCIENTIFIC WORK

The work concentrated in the area of transport properties. More specifically:

1) Maintenance of the Water & Heavy Water Viscosity & Thermal Conductivity Data Bank
As part of a joint project between the International Association for the Properties of Water and Steam and the International Association for Transport Properties (formerly known as Subcommittee on Transport Properties of the International Union of Pure and Applied Chemistry Commission I.2 on Thermodynamics), all available and reliable experimental data on the viscosity and thermal conductivity of ordinary water and steam, as well as heavy water, have been collected and converted to the current temperature scale (ITS-90) and a common set of units. The data are grouped according to state into four regions: liquid phase (excluding data at 0.101 325 MPa), steam (vapor) phase, supercritical phase ($T>T_c$ for any pressure), and liquid at ambient pressure (0.101 325 MPa) between the triple point temperature and the normal boiling point temperature. Moreover, in the case of water, for each point with measured temperature and pressure (or at specified saturation conditions) a density has been computed with the current scientific standard thermodynamic formulation (IAPWS95), and each experimental datum has been compared with the viscosity or thermal conductivity calculated from the current standard formulations for these properties.

Fluid	Property	No of Points	Temperature range (K)	Maximum Pressure (MPa)
Water	Viscosity	4181	254 - 1316	346
	Thermal Conductivity	5111	255 - 1072	785
Heavy Water	Viscosity	1244	277 - 779	468
	Thermal Conductivity	2380	277 - 1043	250

2) Work under IAPWS Collaborative Grant
"Formulations for the Viscosity and Thermal Conductivity of Water and Heavy Water: Evaluated Experimental Database and Initial Correlations"

The task of developing updated formulations for the viscosity and thermal conductivity of water is a very high priority within the Working Group on Thermophysical Properties of Water and Steam. The international effort on this project involves researchers from Russia, United Kingdom, Germany, and Japan, as well as from Greece and the United States. Considerable progress has been made on the task (see, e.g. M.J. Assael, E. Bekou, D. Giakoumakis, D.G. Friend, M. Killeen, J. Millat, and A. Nagashima, "Experimental Data for the Viscosity and Thermal Conductivity of Water and Steam," J. Phys. Chem. Ref. Data 29 (2), 141-166, 2000; A.A. Aleksandrov and A.B. Matveev, "Equation of Dynamic Viscosity in the Region of Existence of the Liquid and Gaseous Phases of Water: Method of Derivation," High Temp. (Russ.) 36, 885-890, 1998; M.J. Assael, V.K. Tsalmanis, N.K. Dalaouti, D. Giakoumakis, and A. Nagashima, "Transport Properties of D_2O: Data Survey & Comparisons," in Steam, Water and Hydrothermal Systems: Physics and Chemistry Meeting the Needs of Industry, Proc. 13th Int. Conf. on the Properties of Water and Steam, NRC Research Press, Ottawa, 2000, P.R. Tremaine, P.G. Hill, D.E. Irish, and P.V. Balakrishnan, eds., pp. 72-79) however a substantial amount of work remains.

Under this specific project, a Greek young scientist, Ms. Metaxa, spent 4 months at NIST. Her tasks included updating databases (incorporating new temperature conversion, as appropriate; searching current literature; introducing uncertainties in all variables; performing additional evaluation); working with NIST statisticians in developing/evaluating formal schemes to achieve consensus values; collecting, re-optimizing and evaluating existing formulations and approaches for viscosity of water; developing and implementing structural optimization algorithms for viscosity; and working with team members to incorporate terms for critical-region behavior. Substantial progress in all of these areas was achieved and a separate report describing these activities is available.

3) New Formulation for the Viscosity of Water

Work in this area is presently progressing fast with the cooperation of Dr D. Friend and Prof. J. Sengers (USA), Prof. E. Vogel (Germany), and A. Nagashima (Japan). It is hoped that a new improved formulation for the viscosity of water will be proposed at the ICPWS Meeting in Kyoto 2005. The new formulation for the viscosity, η, will have a better theoretical form, which is described by the following equation

$$\eta = (\eta_0 + \eta_1 + \eta_{ex})\eta_{cr}$$

where, η_0, is the viscosity at the dilute gas limit, η_1, the initial density dependence, η_{ex}, the excess viscosity, and η_c, the viscosity in the critical region.

a) Viscosity at the Dilute Gas Limit

Following the 4-month stay of Ms Metaxa in NIST, the work on the viscosity of water vapor at the dilute gas limit, has successfully been concluded with the cooperation of Dr Dan Friend at NIST (USA), and Prof. E. Vogel (Germany). Thus, a modified form of the IAPWS 1997 formulation is proposed for the viscosity of water vapor at the dilute gas limit.

In order to derive this form, more data than the existing correlations, were employed. The data were evaluated using an extension of the international recommended procedure for Key Comparison Reference Values with the cooperation of the Statistics Division at NIST. The resulting proposed equation has a 1.6% uncertainty at the 95% confidence limit.

b) Initial density dependence contribution

Work is under way in cooperation with Prof. E. Vogel (Germany). It should be concluded by end of September 2003.

c) Excess Viscosity and Critical Contribution
Work in these areas will start after completion of the previous task.

4) New Formulation for the Viscosity of Heavy Water
Following the above procedure for the viscosity of water, work is under progress to develop a new formulation for the viscosity at the Dilute-Gas Limit.

NON-SCIENTIFIC WORK

Work is still under progress in forming a full National Committee. Although some industries and institutions have responded positively, no National Committee has as yet been appointed. Nevertheless, it is hoped that a committee will be appointed before Christmas 2003.

Attachment 17

Current Status of Research Activities in Japan
Submitted to the Executive Committee Meeting, IAPWS, Vejle, Denmark, August 2003

by

Japanese National Committee
International Association for the Properties of Water and Steam
c/o The 139th Committee on Steam Properties
Japan Society for the Promotion of Science (JSPS)
6, Ichiban-cho, Chiyoda-ku
Tokyo 102-8471, Japan

The Japanese National Committee to the IAPWS is playing an active function as the 139th Committee on Steam Properties chaired by Professor Koichi Watanabe, Keio University, at the Japan Society for the Promotion of Science (JSPS), Tokyo. The Committee is extensively concentrating every effort on the preparation of the forthcoming 14th ICPWS to be held in Kyoto, from August 29 through September 3, 2004. Your positive submission of abstracts and participation are highly appreciated. Please do visit the Website (http://14icpws.iapws.jp/).

The following research projects on the thermophysical and physico-chemical properties of water substances including various aqueous systems of technological importance are currently in progress at several universities and institutions in Japan.

At the Division of Chemistry, Graduate School of Science, Hokkaido University, Sapporo, Prof. S. IKAWA and coworkers are engaged in spectroscopic measurements of water-hydrocarbon mixtures at high temperatures and pressures. Infrared and near infrared measurements of water-aromatic hydrocarbon mixtures in the temperature range 473 – 648 K and the pressure range 10 – 35 MPa have been performed. By analyzing these experimental results, π-hydrogen bonding between water and aromatic hydrocarbons at high temperatures and pressures has been discussed on the basis of a charge transfer theory [*J. Chem. Phys*., **117** (2), 751 (2002)]. Anomalously large volume expansion for mixing of water and benzene has been found in the vicinity of the critical region of the mixtures [*J. Chem. Phys*., **117** (4), 1682 (2002)]. Similar phenomena have been observed for mixtures of water with toluene and ethylbenzene [*Fluid Phase Equilib*. (2003) in press], and the anomalous volumetric behavior is considered to be common to hydrophobic hydrocarbons in the vicinity of the critical region. [contact: Prof. S. Ikawa; E-mail: sikawa@sci.hokudai.ac.jp].

At the Department of Quantum Science and Energy Engineering, Graduate School of Engineering, Tohoku University, Sendai, Prof. S. UCHIDA is promoting a new project on IASCC (Irradiation Assisted Stress Corrosion Cracking) of BWR core internals as a part of studies on life management of aged nuclear power plants. The effects of hydrogen peroxide on IGSCC of stainless steel in high temperature pure water have been examined by using the high temperature high pressure hydrogen peroxide water loops with controlled hydrogen peroxide concentrations and lower possible oxygen concentrations. The characterization results of oxide films confirmed that the oxide film formed under the H_2O_2 environment consists mainly of hematite (α-Fe_2O_3), while that under the O_2 environment consists of magnetite (Fe_3O_4). Furthermore oxidation at the very surface of the film is much more enhanced under the H_2O_2 environment than that under the O_2 environment. It was speculated that metal hydroxide plays an important role in oxidation of stainless steel in the presence of H_2O_2. The difference in electric resistance of oxide film causes the difference in anodic polarization properties. Theoretical approaches to understand crack tip water chemistry under gamma and neutron irradiations are also promoted. The paper (1) was awarded the

2001 Preeminent Monograph Award by Atomic Energy Society of Japan. [Latest publication: (1) Y. Murayama, et al., J. Nucl. Sci. Technol., 39, 1199-1206 (2002), and (2) T. Satoh, et al., J. Nucl. Sci. Technol., 40, 334-342 (2003)] [contact: Prof. S. Uchida; E-mail: shunsuke.uchida@qse.tohoku.ac.jp].

At the Graduate School of Environmental Studies, Tohoku University, Sendai, Profs. N. YAMASAKI, H. ENOMOTO, K. TOHJI, Assoc. Prof. TSUCHIYA, and their group are studying the hydrothermal preparation of advanced materials such as diamond, stratified material on carbon nano- tube using hydrothermal process, and the liquefaction and gasification of heavy oil, the SCWO of rice husk for production of sodium acetate, the separation and extraction of useful materials from bio-mass using superheated steam, and the formation of organic materials by the hydrothermal reduction of carbon dioxide. [contact: Prof. N. Yamasaki; e-mail: yamasaki@igt.earth.tohoku.ac.jp].

At the Institute of Multidisciplinary Research for Advanced Materials, Tohoku University, Sendai, Prof. T. ADSCHIRI and his group are developing a new process of supercritical hydrothermal synthesis of nano particles. Specific features of this method have been found: (i) nano particle formation, (ii) single crystal formation, (iii) ability to control particle morphology to some extent with pressure and temperature, and (iv) ability to provide homogeneous reducing or oxidizing atmospheres by introducing gases or additional components (O_2, H_2). The method can be used for various applications, including magnetic material ($BaO6Fe_2O_3$), phosphor (Tb:YAG), metallic Ni nano particles, Li ion battery material ($LiCoO_2$, $LiMn_2O_4$). For the rational design of this process, they developed a simulation method of supercritical hydrothermal synthesis, based on the fluid dynamics at supercritical conditions, kinetics, solubility estimation, nucleation, particle growth, and particle coagulation. [contact: Prof. T. Adschiri; e-mail: ajiri@tagen.tohoku.ac.jp]

At the Material Properties and Metrological Statistics Division, National Metrology Institute of Japan (NMIJ, formerly NRLM), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, a section lead by Dr. K. FUJII is working on the density and viscosity standards. Absolute density measurements of silicon crystals with a relative standard uncertainty of 7×10^{-8} and a determination of the Avogadro constant by the X-ray crystal density (XRCD) method are conducted for replacing the present definition of the kilogram in the SI units [K. Fujii, A. Waseda, N. Kuramoto, S. Mizushima, M. Tanaka, S. Valkiers, P. Taylor, R. Kessel, and P. De Bièvre, "Evaluation of the Molar Volume of Silicon Crystals for a Determination of the Avogadro Constant," *IEEE Trans. Instrum. Meas.*, **52** (2003), 646-651]. The data are being used for the next adjustment of the fundamental physical constants recommended by the CODATA Task Group on Fundamental Constants. Using the silicon density standard densities of standard liquids are being calibrated by a magnetic suspension density meter developed at NMIJ. A relative standard uncertainty of 6×10^{-6} has been achieved in the density measurement of organic liquids that are used as Certified Reference Materials (CRMs) for calibrating vibrating-tube densimeters. In his group a new absolute viscosity measurement using a falling ball method is in progress. Nano-technologies for measuring the falling distance and diameters of small silicon spheres are developed for providing reference data of transport properties of liquid water with a relative standard uncertainty of 0.01 %. Dr. K. FUJII is working as a chairman of the WG-Density, CCM (Consultative Committee for Mass and Related Quantities) to organize the research activities on the density standards at National Metrology Institutes. A new density-of-water table that has a specified isotopic abundance was proposed by the WG-Density and recently approved by the CCM [M. Tanaka, G. Gerard, R. Davis, A. Peuto, and N. Bignel, "Recommended table for the density of water between 0 °C and 40 °C based on recent experimental reports," *Metrologia*, **38** (2001), 301-309]. This new table is recommended as a metrological standard for the density of SMOW [contact: Dr. K. Fujii, Section Chief, Density and Viscosity Standards, NMIJ; E-mail: fujii.kenichi@aist.go.jp].

At the Division of Environmental Materials & Energy, Dept. Environmental Science & Technology, Faculty of Engineering, Shinshu University, Nagano, Prof. H. Takaku works since Feb. 1 of 2000, and previously worked at Central Research Institute of Electric Power Industry (CRIEPI). In the simulated geothermal waters containing the mixed corrosive chemicals such as chlorides, sulfides, carbon dioxide and others, he and coworkers are studying the corrosion of the steam turbine materials for

geothermal power plants and also that of Ti-Ni base shape memory alloys for geothermal engine actuators. They are studying the on-line corrosion monitoring of boiler materials in fossil power plants, using mainly the electrochemical methods. [Latest publications: (1) N. Kawai, H. Takaku, et al, *Zairyo-to-Kankyo* (*J. Corrosion Eng. in Japan*), **49** (2000), 612-618, (2) T. Sakuma, H. Takaku, et al, *Transactions of Materials Research Society of Japan*, **26** (2001), 167-170, (3) H. Takaku, et al, *Materials Transactions*, **43** (2002), 840-845] [Contact: Prof. H. Takaku; E-mail: takakuh@gipwc.shinshu-u.ac.jp]

Mr. K. MIYAGAWA is developing Tubular Taylor Series Expansion Method (TTSE) for rapid calculation of thermodynamic properties of water substance and other fluid. In the IAPWS meeting in Buenos Aires in 2002, it was decided that the TTSE method should be accepted as an IAPWS guideline entitled " Guideline on the Tabular Taylor Series Expansion (TTSE) Method for Calculation of Thermodynamic Properties of Water and Steam Applied to IAPWS-95 as an Example". Following the decision, he submitted a draft of the guideline to the Editorial Committee. The draft has been distributed by Executive Secretary to National Committees for postal vote. Mr. Miyagawa is developing a new version of TTSE programs that calculates transport properties with high speed and high accuracies. This version will be useful to analyze
transient phenomena in heat transfer and fluid mechanics. [contact: Mr. K. Miyagawa; E-mail: miyagawa.kiyoshi@nifty.ne.jp]

At the Department of Mechanical Sciences and Engineering, Tokyo Institute of Technology, Tokyo, Prof. A. SAITO, Assoc. Prof. S. OKAWA, and their group are studying the effect of oxidation on freezing of supercooled water, and finding that the oxidation of the surface restrain the supercooled water on the surface from freezing [Int. J. Refrigeration, 25 (6) (2002), 25, 5, 514-520]. They are also studying the melting phenomenon of porous material by direct contact melting [12th Int. Heat Transf. Conf., (in CD-ROM), (2002)], and the effect of various kinds of external forces on freezing of supercooled water [6th ASME-JSME Thermal Engineering Joint Conference, (in CD-ROM), (2003)] [contact: Dr. S. Okawa; E-mail: sokawa@ mech.titech.ac.jp].

At the Energy Materials Science Department (former, the Department of Surface Science), Central Research Institute of Electric Power Industry (CRIEPI), Yokosuka, Tokyo, Dr. M. Domae and his coworker are engaged in a national research project, “Fundamental R&D on Water Chemistry of Supercritical Pressure Water under Radioactive Environment”. Within the program, they are in charge of Raman spectroscopy and zeta potential measurement of metal surfaces in sub- and supercritical water. They also worked a concept of metal separation technique in SCW using change in solubility. [contact: Dr. M. Domae; E-mail: domae@criepi.denken.or.jp]

At the Energy & Mechanical Engineering Department, Central Research Institute of Electric Power Industry (CRIEPI), Yokosuka, Kanagawa, Mr. E.KODA and Mr. T.TAKAHASHI are advancing the improvement of the computer software to analyze the heat and mass balance of power generation systems. In this study, IAPWS-IF97 was enhanced so as not to indicate the abnormal value also outside the range of validity, and built into the program. And the development of the computational method of inverse functions to improve the computation time and accuracy is advanced. [contact: Mr. E.KODA; E-mail: kouda@criepi.denken.or.jp]

At the Center for Mechanical Engineering and Applied Mechanics, Keio University, Yokohama, Prof. M. UEMATSU and his group are constructing an apparatus for measuring PVT properties of aqueous ammonia mixtures for temperatures to 800 K at pressures up to 200 MPa. The measurements of thermodynamic properties for methanol + water mixtures in a temperature range from 320 K to 420 K at pressures up to 200 MPa were published in the *Journal of Chemical Thermodynamics* 35 (2003) 813-823. The measurements of thermodynamic properties of ammonia + water mixtures in a temperature range from 310 K to 400 K at pressures up to 17 MPa were published in the *Journal of Chemical Thermodynamics* 34 (2002) 807-819 + 1045-1056. [contact: Prof. M. Uematsu; E-mail: uematsu@mech.keio.ac.jp].

At the Department of System Design Engineering, Prof. A. NAGASHIMA and coworkers are studying measurement of transport properties of liquids including aqueous solutions and correlations of fluids properties of environmental concern. [contact: Prof. A. Nagashima; E-mail: nagasima@sd.keio.ac.jp].

At the Department of Mechanical Engineering, Keio University, Yokohama, Dr. K. YASUOKA and his group are studying the molecular dynamics simulation to clarify the mechanism for the dissociation and formation of methane hydrate. They started the molecular dynamics simulation for the adosorption and desorption of ethanol molecules to liquid-vapor water suface. [contact: Dr. K. Yasuoka; E-mail: yasuoka@mech.keio.ac.jp].

At the Department of Mechanical Engineering, Kanagawa Institute of Technology, Atsugi, Prof. K. OGUCHI and his group are measuring the *PVTx* properties of ammonia + water mixtures. They have measured the *PVTx* properties of aqueous dilute solutions of ammonia in the range of temperatures from 265 K to 305 K, pressures up to 16 MPa, densities from 975 kg□m^{-3} to 989 kg□m^{-3}, and compositions up to 0.10 mol% of ammonia including pure water, focusing their attentions on the maximum density phenomena. Some of their results were presented at the 15th Symposium on Thermophysical Properties held in Boulder in 2003. [contact: Prof. K. Oguchi; E-mail: oguchi@me.kanagawa-it.ac.jp].

At the Research Center for Computational Science, Okazaki National Research Institutes, Prof. S. OKAZAKI and his group started quantum-classical molecular dynamics calculation for vibrational relaxation of solute in supercritical water. They are interested in understanding relaxation machanism in terms of time-dependent couplings between solute and solvent in supercritical fluids. They also published their calculation of dielectric constant of supercritica water [T. Mikami and S. Okazaki, J. Chem. Phys., 119 (2003), 4790-4797]. [contact: Prof. S. Okazaki; E-mail: okazaki@ims. ac.jp].

At the Department of Applied Chemistry, Ritsumeikan University, Shiga, Prof. S. SAWAMURA is measuring the solubility of aromatic hydrocarbons and amino acids in water at high pressures up to 400 MPa and the visicosity of aqueous elecrolyte solution at high pressures [see: H. Matsuo, Fluid Phase Equilibria 20 (2002), 227-238. Sawamura, S. et al., J. Phys. Chem. B105 (2001), 2429-2436]. At the same department, Prof. Y. TANIGUCHI and Assoc. Prof. M. KATO are measuring the infrared, Raman, and NMR spectra for biological compounds at high pressures [see: W. Dzwolak, et al, Biochim. Biophys. Acta 1595 (2002), 131-144; K. Fumino, et al. J. Mol. Liq. 100 (2002), 119-128; R. Kitahara, et al., Protein Science, 12. 207-217 (2003); Y. Shiratori, et al., Bull. Chem. Soc. Jpn, 76 (2003), 501-507.] (contact: Prof. Sawamura, S.; sawamura@se.ritsumei.ac.jp).

At the Institute for Chemical Research, Kyoto University, Uji, Kyoto, Prof. M. NAKAHARA, Dr. N. MATUBAYASI, Dr. C. WAKAI, and their coworkers study the structure, dynamics, and reactions in super- and subcritical water by means of multinuclear NMR (nuclear magnetic resonance) spectroscopy, Raman spectroscopy, and computer simulation. Their current focus are (1) the thermodynamics, structure, and dynamics of aqueous solutions over a wide range of thermodynamic conditions ["Theory of solutions in the energy representation. II. Functional for the chemical potential", N. Matubayasi and M. Nakahara, J. Chem. Phys. 117, 3605-3616 (2002)] and (2) the molecular mechanism of noncatalytic reactions in hydrothermal conditions ["Noncatalytic Cannizzaro-type Reaction of Acetaldehyde in Supercritical Water", Y. Nagai, C. Wakai, N. Matubayasi, and M. Nakahara, Chem. Lett. 32, 310-311 (2003)]. [contact: Prof. M. Nakahara; E-mail: nakahara@scl.kyoto-u.ac.jp]

At the department of Molecular Science and Technology, Doshisha University, Kyotanabe, Prof. M. UENO and his group are studying the conductivities of electrolytes in water and methanol at high temperatures and pressures to disclose the general trends of the density dependence of ionic mobilities at medium and low densities. They are trying to measure the critical micelle concentration at high temperatures and pressures by the conductivity method. In addition, the densities and viscosities of formamides-water mixtures at 25°C under high pressure up to 200 MPa have been reported and discussed in terms of the hydrogen bonding between water and amide molecules and the hydrophobic hydration

[Rev. High Press. Sci. Technol., **13** (2003), 134-140]. [Contact: Prof. M. Ueno; E-mail: mueno@mail.doshisha.ac. jp]

At the Department of Mechanical Engineering Science, Kyushu University, Fukuoka, Prof. Emeritus T. ITO and Prof. Y. TAKATA have released the 12.1 version of the Computer Program Package for Thermophysical Properties, PROPATH, which includes those of water substances. This software is available free of charge to any non-profit organizations, and some functions of which are demonstrated at http://www2.mech.nagasaki-u.ac.jp/PROPATH/ . [contact: Prof. Y. Takata; E-mail: takata@mech.kyushu-u.ac.jp or http://propath.mech.kyushu-u.ac.jp/].

At Mitsubishi Heavy Industries, Ltd., Nagasaki R&D Center, Mr. T. MORIMOTO and his coworkers are studying the oxygenated water treatment for super- and sub-critical thermal power plants and Mr. M. TATEISHI and his coworkers are studying the hydrothermal decomposition of organic compounds such as poly-chlorinated bi-phenyl (PCB) and Dr. J. IZUMI and his coworkers are studying the water treatment for geothermal plants, studying the solubility of hydroxy- and fluoro-apatite in hot water for radioactives storage, and also studying the molecular simulation to assume the solubility of inorganic compounds in hot water [contact: Dr. J. Izumi; E-mail: junizumi@ngsrdc.mhi.co.jp].

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Attachment 18

REPORT OF RUSSIAN NATIONAL COMMITTEE (2002 – 2003)

LIST OF PUBLICATIONS

1. Kostrikina E.Yu., Modestova T.D., Uliyanenko B.I. *et.al.*: An Experience of Boiler Lay-up with the Less Toxic Inhibitor. Energetik, 2002, No.9.
2. Elov A.I., Reshetov A.L., Lopatkin B.V., Gerasimov V.A.: The Automatic Control System of Water Treatment Technological Processes at Yuzhnouralskaya GRES. Elektricheskie Stantcii, 2002, No. 11.
3. Valyashko V.M., Urusova M.A.: Solubility of Sodium Carbonate in the System Na_2CO_3 – NaCl – H_2O at Elevated Temperature and Pressure. Journal of Inorganic Chemistry, 2002, Vol. 47, No. 10, pp. 1723-1727.
4. Valyashko V.M.: Derivation of Complete Face Diagram for Ternary Systems with Immiscibility Phenomenon and Salt Liquid Equilibrium. Pure Appl. Chem., 2002, No. 10, pp. 1871-1884.
5. Man'kina N.N., Zhuravlev L.S., Kirilina N.N. *et al.*: The Practical Results of the Application of Oxygen-Steam Cleaning and Passivation of the Boilers with Natural Circulation. Elektricheskie Stantcii, 2002, No. 9.
6. Larin B.M., Bushuev E.N., Kosyulina E.V.: Increasing the Information Content in Monitoring the Water Chemistry of the Condensate–Feedwater Path of Power Units. Teploenergetika, 2003, No. 7, p. 2-9.
7. Prozorov V.V., Lysenko A.A.: Mechanisms for Protecting Oxide-Coated Steels in Anodic Inhibitor Solutions and When Conducting Neutral-Oxygen Water Chemistry. Teploenergetika, 2003, No. 7, p. 9-13.
8. OchkovV.F., Pilshikov A.P., Solodov A.P., Chudova Yu. V.: Analysis of Ion-Exchange Isotherms Using the Mathcad Software Package. Teploenergetika, 2003, No. 7, p. 13-19.
9. Bogachev A.F., Ostrovskaya M.V.: Analyzing the Water Chemistry and the Condition of the Heating Surfaces of the Heat-Recovery Boilers after the Experimental and Commercial Operation of the PGU-450 Combined-Cycle Power Unit at the Severo-Zapadnaya Thermal Power Station. Teploenergetika, 2003, No. 7, p. 19-23.
10. Dubrovsky I.Ya., Eskin N.B., Tugov A.N., Anikeev A.V.: The Adsorption of Octadecylamine on Boiler Steels under Conditions of a Once-Through Subcritical Pressure Boiler, Teploenergetika, 2003, No. 7, p. 23-24.
11. Yurchevsky E.B., Komarova I.V., Galkina N.K., YakovlevA.V., Anfilov B.G., Kiseleva S.A.: Predicting the Performance of Countercurrent Ion Exchangers Using a Mathematical Modeling Technique. Teploenergetika, 2003, No. 7, p. 24-29.
12. Veselovskaya E.V.: The Protection of Ion-Exchange Filters of Water Treatment Installations against Organic Impurities of Anthropogenic Origin. Teploenergetika, 2003, No. 7, p. 29-35.
13. Endrukhina O.V., Voronov V.N.: Mathematical Modeling of the Water Chemistry of a Thermal Power Station under Unsteady Conditions. Teploenergetika, 2003, No. 7, p. 60-63.
14. Nevedrov A.V., Ushakov G.V.: The Comparative Analysis of the Physical Methods of Water Treatment for the Decreasing of Scale Formation. Teploenergetika, 2003, No. 11, p. 62.

15. Petrova T.I., Ryzhenkov V.A., Kurshakov A.V., Zroichikov A.A., Chernov V.F., Galas I.V.: An Application of Film Forming Amine for the Lay-up of Heat Engineering Equipment at Thermal Power Station-23 OAO Mosenergo. Teploenergetika, 2003, No. 9, p. 56.
16. Khodyrev B.N., Fedoseev B.S., Korovin V.A., Sherbinina S.D., Schukina M.Yu., Suslov S.Yu.: Standardization of Organic Impurities Contents in the Water - Steam Circuit of Power Units Working on Neutral Oxygen Water Chemistry. Elektricheskie Stantcii, 2003, No. 8, p.16.
17. Rubashov A.M., Balaban-Irmenin Yu.V.: New Estimation Procedure of the Intensity of Inner Corrosion of Heat Network Pipelines Metal. Energetik, 2003, No.3, p.30.
18. Zhgenti Yu.V., Palmer D.A., Benezeth P., Wesolowski D.J., Anovitz L.M.: An Experimental Investigation of Borate/Lithium Adsorption from Solution onto Zirconium Dioxide Surfaces. 9th annual International Scientific and Technical Conference of Under-graduate and Post-Graduate Students "Radio-Electronics, Electrical and Power Engineering" REEPE-2003, 4-5 March, 2003, Moscow, Vol. 3, pp.113-114.
19. Makrushin V.V., Perova T.I.: The Factors Influenced on Deposits Formation Processes in Boilers Tubes. 9th annual International Scientific and Technical Conference of Under-graduate and Post-Graduate Students "Radio-Electronics, Electrical and Power Engineering" REEPE-2003, 4-5 March, 2003, Moscow, Vol. 3, pp.122-123.
20. Furunzhieva A.V., Petrova T.I.: Studying of the Polyamines Influence on the Corrosion Rate of Brass and Carbon Steel at Temperatures Under 100 ^{0}C. 9th Annual International Scientific and Technical Conference of Under-graduate and Post-Graduate Students "Radio-Electronics, Electrical and Power Engineering" REEPE-2003, 4-5 March, 2003, Moscow, pp. 129-130.
21. Furunzhieva A.V., Petrova T.I.: About he Using of Polyamines at Power Establishments. 9th Annual International Scientific and Technical Conference of Under-graduate and Post-Graduate Students "Radio-Electronics, Electrical and Power Engineering" REEPE-2002, February 28-March 1, Moscow: Vol. 3, pp. 130.
22. Starikova O.V., Ryzgenkov V.A.: An Investigation of Anticorrosion Properties of Abrasion-Resistant Ion-Plasmous Coatings at Conditions of High Aggressive Mediums. 9th Annual International Scientific and Technical Conference of Under-graduate and Post-Graduate Students "Radio-Electronics, Electrical and Power Engineering" REEPE-2002, February 28-March 1, Moscow: Vol. 3, pp. 128-129.
23. Valyashko V.M., Urusova M.A.: Solubility and Behavior Ternary Water Salt Systems at Sub – and Super Critical Conditions. Monat. Chem., 2003, Vol. 134, pp. 679-692.

For more Russian Journal information, please see the following websites:

TEPLOENERGETIKA *issued in English under the name "Thermal Engineering"*
http://www.maik.ru
ENERGETIK *(POWER ENGINEER), issued in Russian*
http://www.energy-journals.ru/energetic/index.htm
VODOSNABZGENIE I SANITARNAYA TEHNIKA *(WATER SUPPLY AND SANITARY ENGINEERING), issued in Russian*
http://www.vstmag.ru
ELEKTRICHESKIE STANTCII (*POWER STATIONS), issued in Russian*
http://www.energy-journals.ru/electr_st/index.htm

Attachment 18

VESTNIK MEI *(BULLETIN of MOSCOW POWER ENGINEERING INSTITUTE), issued in Russian, abstracts are in English*
http://www.mpei-publishers.ru/vestnik.asp

Dr. Petrova T.I. consisting of creative group was rewarded with the First Degree Diploma and the Gold Medal at 51th Worldwide Salon of Innovation of Scientific Developments and New Technologies Brussels – Eureka - 2002 for the development of method of decreasing corrosion rate of power equipment.

Head of RNC Aleksandrov A.A.

Attachment 19

US National Committee Progress Report

Vejle, Denmark, Aug. 2003

The ASME Subcommittee on Properties of Steam (which is also the U.S. National Committee to IAPWS) completed an update (Version 1.1) to the ASME Steam Properties software based on IAPWS-IF97.

Physical and Chemical Properties Division (838), NIST, Boulder, CO.

D.G. Friend, A.H. Harvey, E.W. Lemmon, J.W. Magee, I. Metaxa, I.M. Abdulagatov, M.M. Aliev

In collaboration with theoretical chemists in England, we have continued our work on development of intermolecular pair potentials for aqueous systems and calculation of second virial coefficients. In the past year, we completed our first system with a diatomic gas: water/hydrogen. As with previous systems, second virial coefficients for the water/gas pair were considered more accurate than those available from experiment.

A new correlation has been developed (A.H. Harvey and E.W. Lemmon, J. Phys. Chem. Ref. Data, in press) for the second virial coefficient B(T) of ordinary water. Compared to the best previous correlation (Hill and MacMillan, 1989), the new correlation makes use of some new data and covers a larger temperature range.

In collaboration with researchers in Argentina, high-temperature solubility data have been analyzed for 14 solutes in H2O and 7 solutes in D2O. These data, expressed both in terms of Henry's constant and the vapor-liquid distribution coefficient, have been correlated to expressions that exhibit the theoretically correct behavior as the critical temperature of the solvent is approached. This work has been published in J. Phys.Chem. Ref. Data.

Work is continuing on the joint IAPWS and IUPAC efforts to update the formulations for the transport properties of water and steam. I. Metaxa from Greece spent 3 months in Boulder on an IAPWS grant and made significant progress on the low-density viscosity.

NIST played the leading role in organizing the 15th Symposium on Thermophysical Properties, held in Boulder in June of 2003. There were five special sessions on Properties of Aqueous Systems, and material relevant to IAPWS was also presented in sessions on Environmental Applications and Molecular Simulation. See http://symp15.nist.gov for details.

We are continuing to collaborate with the Dagestan Scientific Center of the Russian Academy of Sciences (DSCRAS) in the area of thermophysical properties measurements, largely on aqueous systems. In the past year, papers were completed on experimental studies of methanol + water mixtures with calorimeters at NIST and at the DSCRAS; part of this work (visit to Boulder by Mr. Aliev, a doctoral candidate at the DSCRAS) was supported by IAPWS.

Attachment 19

Research Directions and Key Publications: 2002-2003

The Energy Institute Electrochemical Laboratory
The Pennsylvania State University, University Park, PA, 16802

Professor S.N. Lvov (814-863-8377, lvov@psu.edu), Program Coordinator

High Temperature Electrochemistry - General

1. Lvov S.N. Electrochemistry of High Temperature Subcritical and Supercritical Aqueous Systems, Volume 5 in "Encyclopedia of Electrochemistry" (D.D. Macdonald, Ed.) Wiley-VCH, 2003 (in press).

2. Lvov S.N. and Palmer D.A. Electrochemical Studies of High-Temperature Aqueous Systems, Chapter 12 in "The Physical and Chemical Properties of Aqueous Systems at Elevated Temperatures and Pressures: Water, Steam and Hydrothermal Solutions" (D.A. Palmer, R. Fernandez-Prini and A.H. Harvey, Ed.s), Wiley, 2003 (in press).

High Temperature Proton Exchange Membrane Fuel Cells

1. Fedkin M.V., Zhou X.Y., Hofmann M.A., Chalkova E., Weston J.A., Allcock H.R., Lvov S.N. Evaluation of Methanol Crossover in Proton-Conducting Polyphosphazene Membranes, Materials Letter, 2002, v. 52, 192-196.

2. Chalkova E., Zhou X.Y., Ambler C.M, Hofmann M.A., Weston J.A., Allcock H.R., and Lvov S.N. Sulfonimide Polyphosphazene-Based Hydrogen/Oxygen Fuel Cells, Electrochemical and Solid State Letters, **10**, 2002, 221-223.

3. Hofmann M. A., Ambler C. M., Maher A. E., Chalkova E., Zhou X. Y., Lvov S. N., Allcock H. R. Synthesis of Polyphosphazenes with Sulfonimide Side Groups. Macromolecules, **35**, 2002, 6490-6493.

4. Allcock H. R., Hofmann M. A., Ambler C. M., Lvov S. N., Zhou X. Y., Chalkova E., Weston J. Phenylphosphonic Acid Functionalized Poly[aryloxyphosphazenes] as Proton-Conducting Membranes for Direct Methanol Fuel Cells. J. Membrane Science, **202**, 2002, 47-54.

5. Zhou X. Y., Hofmann M. A., Weston J.A., Chalkova E., Allcock H. R., and Lvov S.N., High Temperature Methanol Crossover in Proton-Conducting Polyphosphazene Membranes: In Direct Methanol Fuel Cells, Narayanan, S., Zowodzinski, T. and Gottesfeld, S., Eds.; The Electrochemical Society Proceedings Series: Pennington, NJ, 2002, 34-41.

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High Temperature Potentiometery and pH measurements

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A chapter on "Near-Critical Behavior of Aqueous Systems" by M.A. Anisimov, J.V. Sengers, and J.M.H. Levelt Sengers was completed for the forthcoming IAPWS Handbook on The Physical and Chemical Properties of Aqueous Systems at Elevated Temperatures and Pressures: Water, Steam and Hydrothermal Solutions.

Jan V. Sengers participated in the meeting of the task group on the transport properties of H2O which was held in conjunction with the 15th Symposium on Thermophysical Properties, held in Boulder, CO, June 2003.