

# Curriculum Vitae – Robert Ivkov

## I. Demographic Information and Personal Information

**Current Appointments:** Visiting Assistant Professor  
Johns Hopkins University  
Department of Radiation Oncology and Molecular Radiation  
Sciences

Guest Researcher  
Center for Neutron Research  
National Institute of Standards and Technology  
Gaithersburg, MD

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**Education:** 1987, B. Sc., Andrews University, Chemistry

1990, M. Sc., University of Toronto, Physical Chemistry  
Advisor: John P. Valleau  
Thesis: A Monte Carlo Study of Electric Double Layers

1997, Ph. D., University of Maryland, College Park, P. Chemistry  
Advisor: Sandra C. Greer  
Thesis: Experimental Studies of the Equilibrium Polymerization of  
Muscle Actin

National Research Council Postdoctoral Fellow, 1997  
Polymers Division, National Institute of Standards and  
Technology, Gaithersburg, MD

### **Professional Experience:**

**1990-1994** Teacher, Secondary School; Takoma Academy, Takoma Park, MD

**1997-1998** National Research Council Postdoctoral Fellow, Polymers Division,  
National Institute of Standards and Technology (NIST), Gaithersburg, MD

- 1998-2001** Instrument Scientist, NIST Center for Neutron Research, NIST, Gaithersburg, MD
- 2001-2002** Staff Scientist, Sensera, Inc., Chelmsford, MA
- 2002** Senior Scientist and Co-Founder, Triton BioSystems, Inc., Chelmsford, MA
- 2003** Project Manager, Triton BioSystems, Inc.
- 2003-2006** Director R&D, Triton BioSystems, Inc.
- 2006-2007** Senior Dir. R&D, Triton BioSystems, Inc.
- 2007-2008** Vice President of R&D, Triton BioSystems, Inc.
- 2008 -** Visiting Assistant Professor, Johns Hopkins University
- 2008-** Guest Researcher, NCNR, NIST

## II. Research Activities

### 1. Peer Reviewed Publications

- (1) J. P. Valleau, **R. Ivkov**, G. M. Torrie, Colloid Stability: The forces between charged surfaces in an electrolyte, *J. Chem. Phys.* **95**, 520-532 (1991).
- (2) **R. Ivkov**, J. G. Forbes, S. C. Greer, The polymerization of actin: Study by small angle neutron scattering, *J. Chem. Phys.* **108**, 5599-5607 (1998).
- (3) Nisato G., **Ivkov R.**, Amis E. J., Structure of charged dendrimer solutions as seen by small-angle neutron scattering, *Macromolecules*, **32**, 5895-5900 (1999).
- (4) Yim H., Kent M., McNamara W. F., **Ivkov R.**, Satija S. K., Majewski J., Structure within epoxy films revealed by solvent swelling: A neutron reflectivity study, *Macromolecules* **32**, 7932-7938 (1999).
- (5) Nisato G., **Ivkov R.**, Amis E. J., Size invariance of polyelectrolyte dendrimers;, *Macromolecules* **33**, 4172-4176 (2000).
- (6) Su T. J., Green R. J., Wang Y., Murphy E. F., Lu J. R., **Ivkov R.**, Satija S. K., Adsorption of lysozyme onto the silicon oxide surface chemically grafted with a monolayer of pentadecyl-1-ol, *Langmuir* **16**, 4999-5007 (2000).

- (7) Yim H., Kent M., Matheson A., **Ivkov R.**, Satija S. K., Majewski J., Smith G. S., Adsorption of poly(styrene sulfonate) to the air surface of water by neutron reflectivity, *Macromolecules* **33**, 6126-6133 (2000).
- (8) Nakatani A. I., **Ivkov R.**, Papanek P., Yang H., Gerspacher M.; Inelastic neutron scattering from filled elastomers; *Rubber Chem. and Techn.*, **73** , 847-863 (2000).
- (9) **Ivkov R.**, Papanek P., Gehring P. M., Krishnamoorti R.; Dynamics of confined polymers measured by inelastic neutron scattering; *Polym. Mat. Sci. Eng. Prep.* **82**, 210 (2000).
- (10) **Ivkov, R.**, Butler, P. D., Satija, S. K., Fetters, L. K.; Effect of solvent flow on a polymer brush: A neutron reflectivity study of the brush height and chain density profile, *Langmuir* **17**, 2999 (2001).
- (11) Zamlyunny, V., Burgess, I., Szymanski, G., Lipkowski, J., Majewski, J., Smith, G., Satija, S., **Ivkov, R.**, Electrochemical and neutron reflectivity studies of spontaneously formed amphiphilic surfactant bilayers at the gold-solution interface, *Langmuir* **16**, 9861-9870 (2000).
- (12) Burgess, I., Zamlyunny, V., Szymanski, G., Lipkowski, J., Majewski, J., Smith, G., Satija, S., **Ivkov, R.**, Electrochemical and neutron reflectivity characterization of dodecyl sulfate adsorption and aggregation at the gold-water interface, *Langmuir* **17**, 3355 (2001).
- (13) Kim, E., Suh, H. R., Kim, H., Char, K., Hong, J., Lee, S. H., Satija, S. K., **Ivkov, R.**, Neutron reflectivity from the monolayer of SAN random copolymer; *Mol. Crystals and Liq. Crystals* **371**, 211-214 (2001).
- (14) Pelton R., Richardson R., Cosgrove T., **Ivkov R.**; The effects of temperature and methanol concentration on the properties of poly(N-isopropylacrylamide) at the air/solution interface; *Langmuir* **17**, 5118-5120 (2001).
- (15) Yim H., Kent M. S., Matheson A., Stevens M., **Ivkov R.**, Satija S., Majewski J., Smith G. S., Adsorption of sodium polystyrene sulfonate at the air-surface of water by neutron reflectivity: Concentration dependence, *Macromolecules*, **35**, 9737-9747 (2002).
- (16) Johnson M.A., Santini C.M.B., Iyer J., Satija S., **Ivkov R.**, Hammond P.T.; Neutron reflectivity of linear-dendritic diblock copolymer monolayers; *Macromolecules* **35**, 231-238 (2002).
- (17) **Ivkov R.**, DeNardo S. J., Daum W., Foreman A., Goldstein R., DeNardo G.L., Application of high amplitude alternating magnetic fields for heat induction of nanoparticles localized in cancer; *Clin Cancer Res*, **11**:7093s-7103s (2005).
- (18) DeNardo, S. J., DeNardo G.L., Miers L. A., Natarajan, A., Adamson, G. N., Gruettner, C., **Ivkov R.**, Development of tumor targeting bioprobes (<sup>111</sup>In-chimeric L6

monoclonal antibody nanoparticles) for alternating magnetic field cancer therapy; *Clin. Cancer Res*, **11**:7087s-7092s (2005).

(19) Norman A. I., **Ivkov R.**, Forbes J. G., Greer S. C., The polymerization of actin: structural changes from small angle neutron scattering; *J. Chem. Phys.* **123**(15): 154904 (2005).

(20) Vorotnikova E., **Ivkov R.**, Foreman A. R., Tries M., Braunhut S. J., The magnitude and time-dependence of the apoptotic response of normal and malignant cells subjected to ionizing radiation versus hyperthermia; *Int. J. Rad. Biol.* **82**(8), 549-559 (2006).

(21) DeNardo, S. J., DeNardo G.L., Natarajan, A., Miers L. A., Foreman A. R., Gruettner, C., Adamson, G. N., **Ivkov R.**; Thermal dosimetry predictive of efficacy of <sup>111</sup>In-Ch L6 nanoparticle AMF induced therapy for human breast cancer in mice; *J. Nucl. Med.***48**(3), 437- 444 (2007) **Cover**.

(22) Gruettner, C., Muller K., Teller J., Westphal F., Foreman A. R., **Ivkov R.**; Synthesis and antibody conjugation of magnetic nanoparticles with improved specific power absorption rates for alternating magnetic field cancer therapy; *J Magnetism and Magnetic Mat.*, **311**, 181-186 (2007).

(23) Hoopes P. J., Strawbridge R. R., Gibson U. J., Zeng Q., Pierce Z. E., Savellano M., Tate J. A., Ogden J. A., Baker I., Foreman A. R., **Ivkov R.**; Intratumoral iron oxide nanoparticle hyperthermia and radiation cancer treatment; *Thermal Treatment of Tissue: Energy Delivery and Assessment IV, Proc. Of SPIE*, **6440**, 6440K (2007); Ed. T. P. Ryan.

(24) **Ivkov R.**, DeNardo S. J., Miers L. A., Natarajan A., Gruettner C., Foreman A. R., DeNardo G. L.; Development of antibody directed nanoparticles for cancer therapy; *Thermal Treatment of Tissue: Energy Delivery and Assessment IV, Proc. Of SPIE*, **6440**, 6440I (2007); Ed. T. P. Ryan.

(25) Lehmann J., Natarajan A., DeNardo G. L., **Ivkov R.**, Foreman A. R., Catapano C., Mirick G., Gruettner C., DeNardo S. J., Nanoparticle thermotherapy and external beam radiation therapy for human prostate cancer cells, *Cancer Biotherapy and Radiopharmaceuticals*, **23**, 265-271 (2008).

(26) Dennis C. L., Jackson A. J., Borchers J. A., **Ivkov R.**, Foreman A. R., Lau J. W., Goernitz E., Gruettner C., The influence of collective behavior on the magnetic and heating properties of iron oxide nanoparticles; *J. Appl. Physics* **103**, 07A319 (2008).

(27) Natarajan, A., Gruettner, C., **Ivkov, R.**, DeNardo, G. L., Mirick, G., Yuan, A., Foreman, A., DeNardo, S. J.; NanoFerrite particle based radioimmunonanoparticles: Binding affinity and in vivo pharmacokinetics, *Bioconjugate Chem.*, **19**, 1211-1218 (2008).

- (28) Dennis C. L., Jackson A. J., Borchers J. A., **Ivkov R.**, Foreman A. R., Hoopes, P. J., Strawbridge, R., Pierce, Z., Goernitz, E., Lau, J. W., Gruettner, C.; The influence of magnetic and physiological behavior on the effectiveness of iron oxide nanoparticles for hyperthermia, *J. Phys. D: Applied Physics* **41**, 1340020 (2008).
- (29) Guistini, A., **Ivkov, R.**, Hoopes, P.J.: An *in vivo* transmission electron microscopy study of injected dextran-coated iron oxide nanoparticle location in murine breast adenocarcinoma tumors versus time, *Thermal Treatment of Tissue: Energy Delivery and Assessment V, Proc. Of SPIE*, **7181**, 71810M-1 (2009).
- (30) Hoopes, P.J., Tate, J.A., Ogden, J.A., Strawbridge, R.R., Fiering, S.N., Petryk, A.A., Cassim, S.M., Guistini, A.J., Demidenko, E., **Ivkov, R.**, Barry, S., Chinn, P., Foreman, A.: Assessment of intratumor non-antibody directed iron oxide nanoparticle hyperthermia cancer therapy and antibody directed IONP uptake in murine and human cells, *Thermal Treatment of Tissue: Energy Delivery and Assessment V, Proc. Of SPIE*, **7181**, 71810P-1 (2009).
- (31) Ogden, J.A., Tate, J.A., Strawbridge, R.R., **Ivkov, R.**, Hoopes, P.J.: Comparison of iron oxide nanoparticle and waterbath hyperthermia cytotoxicity, *Thermal Treatment of Tissue: Energy Delivery and Assessment V, Proc. Of SPIE*, **7181**, 71810K-1 (2009).
- (32) Dennis C. L., Jackson A. J., Borchers J. A., Hoopes P. J., Strawbridge R. R., Foreman A. R., van Lierop J., Grüttner C., **Ivkov R.**; Nearly complete regression of tumors via collective behavior of magnetic nanoparticles in hyperthermia; *Nanotechnology*, **20**, 395103 (2009)

## 2. Patents

- (1) Thermotherapy via targeted delivery of nanoscale particles, US 7,074,175
- (2) Thermotherapy via targeted delivery of nanoscale magnetic particles, US 6,997,863
- (3) Thermotherapy via targeted delivery of nanoscale magnetic particles, PCT/US2002/23650
- (4) Therapy via targeted delivery of nanoscale particles, WO 03/022360
- (5) Therapy via targeted delivery of nanoscale particles using L6 antibodies, US2004/0156846.
- (6) Therapy via targeted delivery of nanoscale particles, US2004/0156852.
- (7) Thermotherapy via targeted delivery of nanoscale magnetic particles (in combination with conventional therapies), US2005/0090732.
- (8) Thermotherapy via targeted delivery of nanoscale magnetic particles in combination with conventional therapies, WO 05/044365A2.

- (9) Magnetic nanoparticle compositions, and methods related thereto, US2005/0271745.
- (10) Devices for targeted delivery of thermotherapy, and methods related thereto, US2006/0142748.
- (11) Magnetic nanoscale compositions, and therapeutic methods related thereto, US2006/0142749.
- (12) Magnetic nanoscale compositions, and therapeutic methods related thereto, US2007/0112339.
- (13) Thermotherapy susceptors and methods of using same, filed January 2008, not yet published, US2008/0213382.

### 3. Invited Presentations

- (1) Small angle neutron scattering studies of a novel living polymer: Actin, 1997 International Conference on Neutron Scattering, Toronto, Aug. 1997.
- (2) The polymerization of actin studied by small angle neutron scattering, Fall National Meeting of the American Chemical Society, Boston, MA, August 1998.
- (3) Structure and Dynamics of Polymers in Confined Geometries: Neutron Studies of Intercalated Clay-Polymer Nanocomposites,—Society of Plastics Engineers-ANTEC '99: *Plastics for Bridging the Millenium*, New York, NY, May 1999.
- (4) Dynamics of biodegradable polymer/clay nanocomposites, Biological and Environmentally Degradable Polymer Society Annual Meeting, New Orleans, LA, August 1999.
- (5) Dynamics of polymers in confined geometries, Michelin Americas R&D Headquarters January 2000.
- (6) SANS investigations of polyelectrolyte dendrimers, Dow Chemical, Midland, MI February 2000.
- (7) Polymer dynamics in intercalated clay-polymer nanocomposites studied by inelastic neutron scattering, Nanocomposites Symposium, Spring National Meeting of the American Chemical Society, San Francisco CA, March 2000.
- (8) Nanofabrication of protein multilayers through alternate adsorption with polyions: Neutron and x-ray structural analysis and bioactivity in dependence on number of layers, LB9 The Ninth International Conference on Organized Molecular Films, Potsdam, Germany, September 2000.

- (9) Dynamics of clay-polymer nanocomposites measured with inelastic neutron scattering, Fall Meeting of the Materials Research Society, Boston, MA, November 2000.
- (10) Development of tumor targeting magnetic nanoparticles for cancer therapy, 2<sup>nd</sup> Military Health Research Forum of the US Army Medical Research and Materiel Command Peer Reviewed Medical Research Program, San Juan, Puerto Rico, May 2006 – Invited poster.
- (11) Development of tumor targeting magnetic nanoparticles for cancer therapy, Particles 2006 – Medical/Biochemical Diagnostic, Pharmaceutical, and Drug Delivery Applications of Particle Technology, Orlando, FL, May 2006.
- (12) Development of a cancer therapy that combines tumor-targeting magnetic nanoparticles with an alternating magnetic field, NIST Center for Neutron Research, Gaithersburg, MD, November 2006.
- (13) Development of tumor targeting nanoparticles for cancer therapy, SPIE Photonics West, San Jose, CA, January 2007.
- (14) Magnetic nanoparticle heating for cancer: Characterization of a novel therapy, EHE Seminar, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, February 2009.
- (15) Treating cancer with magnets: Fact or fiction? Summer Undergraduate Research Fellows Seminar, National Institute of Standards and Technology, Gaithersburg, MD, July 2009.
- (16) Targeted heating with magnetic nanoparticles, Molecular Radiation Sciences Symposium, Johns Hopkins School of Medicine, Baltimore, MD, May 2009.

### III. Extramural Sponsorship

#### **Contracts**

**2004 – 2008** Development and commercialization of a magnetic nanoparticle-based therapy for cancer

**No.: W81XH-04-C-0142**

**Sponsor:** US Army Medical Research and Materiel Command (USAMRMC)

**Total Award: \$4,000,000**

**Principal Investigator:** Robert Ivkov

### IV. Educational Activities

- 2008** Guest Lecturer, Radiobiology course, Radiation Oncology, Johns Hopkins, Baltimore, NH
- 2006** Guest Lecturer, Biomedical Engineering, Dartmouth College, Hanover, NH

- 1993 – 1995** Teaching Assistant, Physical Chemistry Laboratory, University of Maryland, College Park, MD
- 1990 – 1994** Teacher, Chemistry and Advanced Placement Chemistry, Secondary School, Tacoma Academy, Tacoma Park, MD
- 1987 – 1990** Teaching Assistant, General Chemistry, University of Toronto, Toronto, Canada
- 1983 – 1987** Teaching Assistant, General Physics, General Chemistry, Organic Chemistry, and Biochemistry, Andrews University, Berrien Springs, MI

## V. Editorial Activities

### Ad hoc reviewer for:

*Langmuir, Macromolecules, Physical Review Letters, Cancer, Cancer Biotherapy and Radiopharmaceuticals, and International Journal of Hyperthermia, Optics Express*

### Review committees:

SANS Technical Reviews, NCNR – 1999 to 2001

Reflectometry Technical Review, NCNR – 1999 to 2001

## VI. Awards and Honours

**1986** Dow Chemical Undergraduate summer research grant

**1997** National Research Council Postdoctoral Fellowship

## VII. Organizational Activities

### **Membership in Professional Societies:**

American Chemical Society (ACS), since 1985