

LITERATURE STATUS ON TEMPERATURE-MODULATED DIFFERENTIAL SCANNING CALORIMETRY

J. D. Menczel¹ and L. Judovits²

¹Hoechst Research and Technology U.S., 86 Morris Avenue, Summit, NJ 07901

²Elf Atochem North America, Inc., 900 First Avenue, P.O. Box 61536, King of Prussia PA 19406-0936, USA

Introduction

In this paper we made an attempt to organize the articles published on temperature-modulated differential scanning calorimetry (TMDSC) or publications where TMDSC was used. The purpose of this paper is simply to present a literature summary on TMDSC papers published so far. The literature search was performed through the use of chemical abstracts or found in publications known for TMDSC articles, although other publications may exist which are not noted in our search. These references are subdivided into several different categories, so that the reader can easily locate articles of interest. In addition, the titles of the papers are also given to better help the reader to select the right article. The categories selected are general theory, glass transition analysis, phase transitions, heat capacity, special topics, instrumentation, thermosets, review papers, pharmaceuticals and food science, inorganic and organic chemistry, and degradation or decomposition. The special topics category covers a variety of subjects which include, for example, polymerization, thermal conductivity, and interpenetrating polymer networks. There is some overlap between the categories, for example, some food science papers which dealt with glass transitions were assigned to the glass transition analysis section.

The number of published TMDSC related papers has increased rapidly, from less than 20 articles in 1993 to over 100 written in 1997. More than 300 papers (including lectures and seminars) have been published so far with the use of this new technique. The major application appears to be in the area of thermosets, although interest in its use is growing fast for thermoplastics, food science and pharmaceuticals. Applications for inorganic chemistry and degradation studies can also be found. An international symposium on pharmaceutical and food science application is planned for 1998. A special session is devoted lately to the use of TMDSC at the NATAS and ICTAC conferences.

The most prolific authors, especially in the area of theory, are Reading and Wunderlich although Schawe has also a significant number of theoretical publications. Others are also active in the area of theory, including Hatta, Blaine and Marcus from TA Instruments, Scherrenberg, Mathot, Buehler, Seferis, Ozawa and Kanari, as can be seen in this special issue. Not surprisingly, the journals with the largest number of TMDSC articles are the *Journal of Thermal Analysis and Calorimetry* and *Thermochimica Acta*.

General theory

- J. E. K. Schawe and W. Winter, The influence of heat transfer on temperature modulated DSC experiments, *Thermochim. Acta*, 298 (1997) 9–16.
- K. Kanari and T. Ozawa, Simulation of temperature-modulated DSC of transitions represented by abrupt changes in heat capacity, *J. Thermal Anal.*, 49 (1997) 979–989.
- M. Reading, Comments on 'A comparison of different evaluation methods in modulated-temperature DSC', *Thermochim. Acta*, 292 (1997) 179–187.
- J. E. K. Schawe and G. W. H. Hoehne, The analysis of temperature modulated DSC measurements by means of the linear response theory, *Thermochim. Acta*, 287 (1996) (2) 213–223.
- A. A. Lacey, C. Nikolopoulos and M. Reading, A mathematical model for modulated differential scanning calorimetry, *J. Thermal Anal.*, 50 (1997) 279–333.
- B. Wunderlich, Modeling the heat flow and heat capacity of modulated differential scanning calorimetry, *J. Thermal Anal.*, 48 (1997) 207–224.
- B. Wunderlich, A. Boller, I. Okazaki and S. Kreitmeyer, Linearity, steady state and complex heat capacity in modulated differential scanning calorimetry, *Thermochim. Acta*, 282/283 (1996) 143–155.
- T. Ozawa and K. Kanari, Linearity and non-linearity in DSC: A critique on modulated DSC, *Thermochim. Acta*, 253 (1995) 183–188.
- B. Wunderlich, Y. Jin and A. Boller, Mathematical description of differential scanning calorimetry based on periodic temperature modulation, *Thermochim. Acta*, 238 (1994) 277–293.
- J. E. K. Schawe, Principles for the interpretation of temperature modulated DSC measurements, Part 2: A thermodynamic approach, *Thermochim. Acta*, 304/305 (1997) 111–119.
- G. W. H. Höhne, Evaluation of temperature-modulated differential scanning calorimetric measurements by phase-sensitive rectification techniques, *Thermochim. Acta*, 304/305 (1997) 209–218.
- I. Hatta and N. Katayama, Diagnosis of phase shift in a temperature modulated calorimetric method, *Proc. 25th NATAS*, September 7–9, 1997, McLean, Virginia, pp. 623–630.
- T. Ozawa and K. Kanari, A new theoretical approach to TM-DSC, *Proc. 25th NATAS*, September 7–9, 1997, McLean, Virginia, pp. 633–636.

Glass transition analysis

- J. E. K. Schawe, Description of thermal relaxation of polystyrene close to the thermal glass transition, *J. Polym. Sci., Part B: Polym. Phys.*, 36 (1998) 2165–2175.
- Z. Jiang, C. T. Imrie and J. M. Hutchinson, Temperature modulated differential scanning calorimetry. Part 1: Effect of heat transfer on the phase angle in dynamic ADSC in the glass transition region, *Thermochim. Acta*, 315 (1998) 1–9.
- T. Wagner, S. O. Kasap and M. Vlcek, Modulated differential scanning calorimetry experiments on film and bulk, $(As_{0.33}S_{0.67})_{100-x}Y_x$, ($Y=Te$ or I) glasses, *Thin Solid Films*, 317 (1998) 245–248.

- T. Wagner, S. O. Kasap, M. Vlcek, A. Sklenar and A. Stronski, The structure of As_xS_{100-x} glasses studied by temperature-modulated differential scanning calorimetry and Raman spectroscopy, *J. Non-Cryst. Solids*, 227–230(Pt. B) (1998) 752–756.
- R. Song, X. Lin, J. Chen, J. Gao and Q. Fan, The effect of hot drawn on the physical aging of atactic polystyrene, *Chin. J. Polym. Sci.*, 16 (1998) 176–184.
- L. C. Thomas, A. Boller, I. Okazaki and B. Wunderlich, Modulated differential scanning calorimetry in the glass transition region. IV., *Pseudo-isothermal analysis of the polystyrene glass transition*, *Thermochim. Acta*, 291 (1997) 85–94.
- A. Toda, C. Tomita and M. Hikosaka, A temperature modulated DSC study in poly(ethylene terephthalate), *Prog. Theor. Phys. Suppl.* (1997), 126 (Dynamics of Glass Transition and Related Topics), 103–106.
- T. Wagner, S. O. Kasap and K. Maeda, Glass transformation, heat capacity, and structure of Ge_xSe_{100-x} glasses studied by temperature-modulated differential scanning calorimetry, *J. Mater. Res.*, 12 (1997) 1892–1899.
- S. X. Lu and P. Cebe, Thermal analysis study of the effect of molecular weight on constrained amorphous phase in poly(phenylene sulfide), *J. Thermal Anal.*, 49 (1997) 525–533.
- D. J. Hourston, M. Song, H. M. Pollock and A. Hammiche, Modulated differential scanning calorimetry. III. Applications to measurements of the glass transition temperature and increment of heat capacity, *J. Thermal Anal.*, 49 (1997) 209–218.
- B. Wunderlich and I. Okazaki, Modulated differential scanning calorimetry in the glass transition region. VI. Model calculations based on poly(ethylene terephthalate), *J. Thermal Anal.*, 49 (1997) 57–70.
- G. O. R. A. van Ekenstein, G. T. Brinke and T. S. Ellis, Polymer-polymer miscibility investigated by temperature modulated differential scanning calorimetry, *Polym. Mater. Sci. Eng.*, 76 (1997) 219–220.
- B. Wunderlich and I. Okazaki, Temperature-modulated calorimetry of the frequency dependence of the glass transition of poly(ethylene terephthalate) and polystyrene, *Polym. Mater. Sci. Eng.*, 76 (1997) 217–218.
- M. J. Izzard, S. Ablett, P. J. Lillford, V. L. Hill and I. F. Groves, A modulated differential scanning calorimetric study. Glass transitions occurring in sucrose solutions, *J. Thermal Anal.*, 47 (1996) 1407–1418.
- M. Song, A. Hammiche, H. M. Pollock, D. J. Hourston and M. Reading, Modulated differential scanning calorimetry: 4. Miscibility and glass transition behavior in poly(methyl methacrylate) and poly(epichlorohydrin) blends, *Polymer*, 37 (1996) 5661–5665.
- T. Wagner and S. O. Kasap, Glass transformation, heat capacity and structure of As_xSe_{1-x} glasses studied by modulated temperature differential scanning calorimetry, *Philos. Mag.*, B 74 (1996) 667–680.
- I. Okazaki and B. Wunderlich, Modulated differential scanning calorimetry in the glass transition region. V. Activation energies and relaxation times of poly(ethylene terephthalate)s, *J. Polym. Sci., Part B: Polym. Phys.*, 34 (1996) 2941–2952.
- B. Wunderlich, A. Boller, I. Okazaki and S. Kreitmeier, Modulated differential scanning calorimetry in the glass transition region. II. The mathematical treatment of the kinetics of the glass transition, *J. Thermal Anal.*, 47 (1996) 1013–1026.
- J. E. K. Schawe, Investigations of the glass transitions of organic and inorganic substances. DSC and temperature modulated DSC, *J. Thermal Anal.*, 47 (1996) 475–484.
- A. Hensel, J. Dobbertin, J. E. K. Schawe, A. Boller and C. Schick, Temperature modulated calorimetry and dielectric spectroscopy in the glass transition region of polymers, *J. Thermal Anal.*, 46 (1996) 935–954.
- J. E. K. Schawe, Principles for the interpretation of modulated temperature DSC measurements, Part 1. Glass transition, *Thermochim. Acta*, 261 (1995) 183–194.

- Y. Saruyama, Thermal analysis of polymeric materials by modulation calorimetry around the glass transition temperature, *Kobunshi Ronbunshu*, 53 (1996) 788–794.
- Y. P. Khanna, W. P. Kuhn and W. J. Sichina, Reliable measurements on the Nylon 6 glass transition made possible by the new dynamic DSC, *Macromolecules*, 28 (1995) 2644–2646.
- P. Vast, F. Gomez and M. Chahinian, Principle and advantages of modulated DSC. Application to the study of complex transition in polyphosphate glasses, *Calorim. Anal. Therm.*, 27 (1996) 233–238.
- R. Hassler, Measurement of hidden glass transitions in plastics, *Adhaes.-Kleben Dichtne*, 41 (1997) 31–32, 34–35.
- G. M. Memon and B. H. Chollar, Glass transition measurements of asphalts by DSC, *J. Thermal Anal.*, 49 (1997) 601–607.
- S. L. Simon and G. B. McKenna, The effects of structural recovery in modulated DSC, *Ann. Tech. Conf.-Soc. Plast. Eng.*, (1997), 55th 2232–2237.
- X. Feng, W. J. Bresser and P. Boolchand, Direct evidence for stiffness threshold in chalcogenide glasses, *Phys. Rev. Letters*, 78 (1997) 4422–4425.
- K.-P. Bohn and J. K. Krueger, The thermal glass transition beyond the time trap, Book of Abstracts, 213th ACS National Meeting, San Francisco, April 13–17 (1997), PMSE-159 Publisher: American Chemical Society, Washington, D.C.
- G. O. R. Alberda van Ekenstein, G. ten Brinke and T. S. Ellis, Polymer-polymer miscibility investigated by temperature modulated differential scanning calorimetry, Book of Abstracts, 213th ACS National Meeting, San Francisco, April 13–17 (1997), PMSE-130 Publisher: American Chemical Society, Washington, D.C.
- M. C. Luyten, E. J. F. Boegels, G. O. R. Alberda van Ekenstein, G. ten Brinke, W. Bras, B. E. Komanschek and A. J. Ryan, Morphology in binary blends of poly(vinyl methyl ether) and ϵ -caprolactone-trimethylene carbonate diblock copolymer, *Polymer*, 38 (1997) 509–519.
- S. X. Lu and P. Cebe, Effect of annealing on the disappearance and creation of constrained amorphous phase, *Polymer*, 37 (1996) 4857–4863.
- H. Gao and J. P. Harmon, Viscoelasticity of *p*-alkylated and halogenated polystyrenes, *Polym. Prep. (Am. Chem. Soc., Div. Polym. Chem.)*, 37 (1996) 236.
- A. Boller, I. Okazaki and B. Wunderlich, Modulated differential scanning calorimetry in the glass transition region. Part III. Evaluation of polystyrene and poly(ethylene terephthalate), *Thermochim. Acta*, 284 (1996) (1) 1–19.
- L. N. Bell and D. E. Touma, Glass transition temperatures determined using a temperature-cycling differential scanning calorimeter, *J. Food Sci.*, 61 (1996) 807–810, 828.
- T. Provder, E. Meyer, C. Michalski, L. Bender and S. Burke, Application of thermal analysis methods to coatings product research and development, Book of Abstracts 212th ACS National Meeting, Orlando, FL, August 25–29 (1996), PMSE-143 Publisher: American Chemical Society, Washington, D.C.
- D. I. Hourston and F.-H. Schafer, Polyurethane-polystyrene one-shot interpenetrating polymer networks with good damping ability: transition broadening through crosslinking, inter-network grafting and compatibilization, *Polym. Adv. Technol.*, 7 (1996) (4) 273–280.
- H. Gao and J. P. Harmon, Viscoelasticity of *p*-alkylated and halogenated polystyrenes, Book of Abstracts, 212th ACS National Meeting, Orlando, FL, August 25–29 (1996), POLY-072 Publisher: American Chemical Society, Washington D.C.
- C. Tomasi, P. Mustarelli, N. A. Hawkins and V. Hill, Characterization of amorphous materials by modulated differential scanning calorimetry, *Thermochim. Acta*, 278 (1996) 9–18.
- S. Jiarui, Y. Wei and Z. Shuihan, Miscibility and mechanical properties for blends of sulfonated polystyrene with polyurethane, Book of Abstracts, 211th ACS National Meeting, New Orleans, LA, March 24–28 (1996), POLY-123 Publisher: American Chemical Society, Washington, D.C.
- J. Hutchinson and S. Montserrat, The application of modulated differential scanning calorimetry to the glass transition. Theoretical analysis using a single parameter model, *J. Thermal Anal.*, 47 (1996) 103–116.

- J. M. Hutchinson and S. Montserrat, The application of modulated differential scanning calorimetry to the glass transition of polymers. I. A single-parameter theoretical model and its predictions, *Thermochim. Acta*, 286 (1996) 263–296.
- D. J. Hourston, M. Song, A. Hammiche, H. M. Pollock and M. Reading, Modulated differential scanning calorimetry. 2. Studies of physical aging in polystyrene, *Polymer*, 37 (1996) 243–247.
- A. Boller, C. Schick and B. Wunderlich, Modulated differential scanning calorimetry in the glass transition region, *Thermochim. Acta*, 266 (1995) 97–111.
- T. F. Turner, S.-S. Kim, J. F. Branthaver and J. F. McKay, Chemical compositional effects on glass transition phenomena in asphalt, Book of Abstracts, 210th ACS National Meeting, Chicago, IL, August 20–24 (1995), Issue Pt. 1, I&EC-081 Publisher: American Chemical Society, Washington, D.C.
- M. Song, A. Hammiche, H. M. Pollock, D. J. Hourston and M. Reading, Modulated differential scanning calorimetry: 1. A study of the glass transition behavior of blends of poly(methyl methacrylate) and poly(styrene-co-acrylonitrile), *Polymer*, 36 (1995) 3313–3316.
- S. R. Sauerbrunn, R. L. Blaine and J. A. Foreman, Effect of aging on the enthalpic relaxation of amorphous PET, *Ann. Tech. Conf.-Soc. Plast. Eng.*, 52 (1994) 2156–2159.
- V. T. Truong, B. C. Ennis and M. Forsyth, Enhanced thermal properties and morphology of ion-exchanged polypyrrole films, *Polymer*, 36 (1995) 1933–1940.
- J. Korus, M. Beinci, K. Busse, S. Kahle, R. Unger and E. Donth, Heat capacity spectroscopy at the glass transition in polymers, *Thermochim. Acta*, 304/305 (1997) 99–110.
- J. M. Hutchinson and S. Montserrat, A theoretical model of temperature-modulated differential scanning calorimetry in the glass transition region, *Thermochim. Acta*, 304/305 (1997) 257–265.
- S. Weyer, A. Hensel and C. Schick, Phase angle correction for TMDSC in the glass transition region, *Thermochim. Acta*, 304/305 (1997) 267–275.
- R. Urbani, F. Sussich, S. Prejac and A. Cesàro, Enthalpy relaxation and glass transition behavior of sucrose by static and dynamic DSC, *Thermochim. Acta*, 304/305 (1997) 359–367.
- E. Flikkema, G. Alberda van Ekenstein and G. ten Brinke, Temperature modulated calorimetry of glassy polymers and polymer blends, *Macromolecules*, 31 (1998) 892–898.
- J. M. Hutchinson, Characterising the glass transition and relaxation kinetics by conventional and temperature modulated differential scanning calorimetry, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 342–349.
- S. L. Simon and G. B. McKenna, The effects of structural recovery in MDSC measurements, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 358–365.
- C. Schick and A. Hensel, Relation between freezing-in due to linear cooling and the dynamic glass transition temperature by temperature modulated DSC, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 685–692.
- R. L. Blaine, S. R. Aubuchon and L. C. Thomas, Exploration of the glass transition under isothermal conditions with MDSC, Proc. 24th NATAS, September 10–13, 1995, San Francisco, CA, p. 154.
- Y. P. Khanna, W. P. Kuhn and W. J. Sichina, Reliable measurements of Nylon Tg vs. moisture by DDSC, Proc. 23th NATAS, September 25–28, 1994, Toronto, Ontario, Canada, p. 11.
- A. Boller, C. E. G. Schick and B. Wunderlich, The measurement of the glass transition with modulated DSC and its relation to dynamic mechanical and electrical measurements, Proc. 23th NATAS, September 25–28, 1994, Toronto, Ontario, Canada, pp. 464–469.
- S. I. Kim, S. M. Pyo and M. Ree, Investigation of glass transition behaviors in poly(amic acid) precursors of semiflexible polyimides by oscillating differential scanning calorimetry, *Macromolecules*, 30 (1997) 7890–7897.
- W. J. Sichina and A. Bizet, Determination of the effects of moisture on nylon, *Ann. Tech. Conf.-Soc. Plast. Eng.*, (1994), 52nd (Vol. 2), 2146–2150.

Phase transitions

- J. E. K. Schawe and G. R. Strobl, Superheating effects during the melting of crystallites of syndiotactic polypropylene analyzed by temperature-modulated differential scanning calorimetry, *Polymer*, 39 (1998) 3745–3751.
- M. Ribeiro, A. Boller, L. Rodier, J. P. E. Grolier and B. Wunderlich, Comparative Study by conventional DSC and temperature modulated DSC: heat capacity, enthalpy, degree of crystallinity of polyethylenes, *Calorim. Anal. Therm.*, 28 (1997) 2–7.
- S. X. Lu, P. Cebe and M. Capel, Effects of Molecular Weight on the Structure of Poly(phenylene Sulfide) Crystallized at Low Temperatures, *Macromolecules*, 30 (1997) 6243–6250.
- K. Ishikiriyama and B. Wunderlich, Melting of poly(oxyethylene) analyzed by temperature modulated calorimetry, *Macromolecules*, 30 (1997) 4126–4131.
- A. Toda, T. Oda, M. Hikosaka and Y. Saruyama, A new analyzing method of temperature modulated DSC of exo- or endothermic processes. Application to polyethylene crystallization, *Thermochim. Acta*, 293 (1997) 47–63.
- A. Toda, C. Tomita, H. Masamichi and Y. Saruyama, An application of temperature modulated differential scanning calorimetry to the exothermic process of poly(ethylene terephthalate) crystallization, *Polymer*, 38 (1997) 2849–2852.
- I. Okazaki and B. Wunderlich, Reversible local melting in polymer crystals, *Macromol. Rapid. Commun.*, 18 (1997) 313–318.
- I. Okazaki and B. Wunderlich, Reversible melting in polymer crystals detected by temperature modulated differential scanning calorimetry, *Macromolecules*, 30 (1997) 1758–1764.
- A. Toda, T. Oda, M. Hikosaka and Y. Saruyama, A new method of analyzing transformation kinetics with temperature modulated differential scanning calorimetry: application to polymer crystal growth, *Polymer*, 38 (1997) 231–233.
- J. E. K. Schawe and G. W. H. Hoehne, Modulated temperature DSC measurements relating to the cold crystallization process of poly(ethylene terephthalate). *J. Thermal Anal.*, 46 (1996) 893–903.
- E. A. Komarova, N. A. Kalinina, N. S. Domina and L. K. Dyul'ger, *Zh. Prikl. Khim.* (S.-Peterburg), 70 (1997) 1022–1026.
- D.-M. Fann, S.-K. Huang and J.-Y. Lee, Kinetics and thermal crystallinity of recycled PET. II. Topographic study on thermal crystallinity of the injection-molded recycled PET, *J. Appl. Polym. Sci.*, 61 (1996) 261–271.
- V. B. F. Mathot, R. L. Scherrenberg, M. F. J. Pijpers and W. Bras, Dynamic DSC, SAXS and WAXS on homogeneous ethylene-propylene and ethylene-octene copolymers with high comonomer contents, *J. Thermal Anal.*, 46 (1996) 681–718.
- I. Hatta, H. Ichikawa and M. Todoki, Application of dynamic differential scanning calorimetry to study phase transitions, *Thermochim. Acta*, 267 (1995) 83–94.
- J. Schmidtke, G. Strobl and T. Thurn-Albrecht, A four-state scheme for treating polymer crystallization and melting suggested by calorimetric and small angle X-ray scattering, *Macromolecules*, 30 (1997) 5804–5821.
- J. D. Menczel, G. L. Collins and S. K. Saw, Thermal analysis of Vectran fibers and films, *J. Thermal Anal.*, 49 (1997) 201–208.
- V. E. Reinsch and S. S. Kelley, Crystallization of poly(hydroxybutyrate-co-hydroxyvalerate) in wood fiber reinforced composites, *J. Appl. Polym. Sci.*, 64 (1997) 1785–1796.
- L. Thomas, J. Cattiaux and M. Chahinian, Principle and benefits of modulated DSC. Measurement of the initial crystallinity of polymers, *Spectra Anal.*, 26 (1997) 31–33.
- X. Hu, C. D. Breach and R. J. Young, Elucidation of the hard segment transition in diacetylene containing copolyurethane using modulated differential scanning calorimetry, *Polymer*, 38 (1997) 981–983.

- J. Loos, A. Hueckert and J. Petermann, On the crystallization behavior of cold-drawn syndiotactic polypropylene, *Colloid Polym. Sci.*, 274 (1996) 1006–1011.
- Y.-Y. Cheng, M. Brillhart, P. Cebe and M. Capel, X-ray scattering and thermal analysis study of the effects of the molecular weight on phase structure in blends of poly(butylene terephthalate) with polycarbonate, *J. Polym. Sci., Part B: Polym. Phys.*, 34 (1996) 2953–2965.
- C. D. Breach and X. Hu, Dynamic mechanical spectroscopy and modulated differential scanning calorimetry of an annealed poly(phenylene sulfide), *J. Mater. Sci. Lett.*, 15 (1996) 1416–1419.
- Y. Jin, J. Bonilla, Y.-G. Lin, J. Morgan, L. McCracken and J. Carnahan, A study of PBT/PC blends by modulated DSC and conventional DSC, *J. Thermal Anal.*, 46 (1996) 1047–1059.
- M. Chahinian and L. C. Thomas, Modulated differential scanning calorimetry. Application to the measurement of initial crystallinity of polymers, *Mater. Tech. (Paris)*, 83 (1995) 26–29.
- K.-P. Bohn, A. Prahm, J. Petersson and J. K. Krüger, Modulated differential scanning calorimetry: Investigation at structural phase transitions, *Thermochim. Acta*, 304/305 (1997) 283–290.
- B. D. Dickie, Investigation of an engineering thermoplastic polyurethane by MDSC, *Thermochim. Acta*, 304/305 (1997) 347–352.
- Y. Y. Cheng, M. V. Brillhart and P. Cebe, Modulated differential scanning calorimetry study of blends of poly(butylene terephthalate) with polycarbonate, *Thermochim. Acta*, 304/305 (1997) 369–378.
- J. E. K. Schawe and E. Bergmann, Investigation of polymer melting by temperature modulated differential scanning calorimetry and its description using kinetic models, *Thermochim. Acta*, 304/305 (1997) 179–186.
- I. Hatta, Potentiality of an ac calorimetric method in the study of phase transitions, *Thermochim. Acta*, 304/305 (1997) 27–34.
- M. Castro and J. A. Puértolas, Character of the phase transition in liquid crystals by AC calorimetry, *Thermochim. Acta*, 304/305 (1997) 291–302.
- D. Finotello, S. Qian and G. S. Iannacchione, AC calorimetric studies of phase transitions in porous substrates. Superfluid helium and liquid crystals, *Thermochim. Acta*, 304/305 (1997) 303–316.
- C. Schick, M. Merzlyakov and A. Wurm, Reversible melting probed by temperature modulated dynamic mechanical and calorimetric measurements, *Book of Abstracts, 215th ACS National Meeting, Dallas, TX, March 29– April 2 (1998), PMSE-123, Volume 78, Publisher: American Chemical Society, Washington, D.C.*
- B. B. Sauer and W. G. Kampert, Thermally stimulated currents and temperature modulated DSC studies of semicrystalline materials, *Book of Abstracts, 215th ACS National Meeting, Dallas, TX, March 29– April 2 (1998), PMSE-127, Volume 78, Publisher: American Chemical Society, Washington, D.C.*
- J. Menczel and L. H. Judovits, Effect of molecular weight on reorganization of semicrystalline polymers during melting, *Book of Abstracts, 215th ACS National Meeting, Dallas, TX, March 29– April 2 (1998), PMSE-210, Volume 78, Publisher: American Chemical Society, Washington, D.C.*
- J. Karger-Kocsis and P. P. Shang, A modulated DSC study on the strain-induced $\beta\alpha$ -transformation in a β -form isotactic polypropylene, *J. Thermal Anal.*, 51 (1998) 237–244.
- A. Toda, C. Tomita, M. Hikosaka and Y. Saruyama, Temperature modulated d.s.c. study of poly(ethylene terephthalate) crystallization: 2. Applicability to non-isothermal process, *Polymer*, 39 (1998) 1439–1444.
- C. Schick, M. Merzlyakov and B. Wunderlich, Analysis of the reorganization of poly(ethylene terephthalate) in the melting range by temperature-modulated calorimetry, *Polym. Bull. (Berlin)*, 40 (1998) 297–304.

- B. Wunderlich, I. Okazaki, K. Ishikiriyama and A. Boller, Melting by temperature-modulated calorimetry, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 49–56.
- A.-G. Leray and L. H. Judovits, MDSC and DSC of Nylon 12 and poly(vinylidene fluoride), Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 72–77.
- S. R. Aubuchon, P. Chin and R. L. Hassel, Observation of first-order phase transitions by modulated DSCTM, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 78–85.
- W. Chen, M. Dadmun, G. Zhang, A. Boller and B. Wunderlich, Isotropization of nematic liquid crystals by TMDSC, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 637–644.
- A. Toda, C. Tomita, T. Oda and M. Hikosaka, A new method of analyzing transformation kinetics with TMDSC. (I): crystallization of polymers, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 645–650.
- M. Toda, M. Tomita and M. Hikosaka, A new method of analyzing transformation kinetics with TMDSC. (II): Inversible melting of polymer crystals, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 659–666.
- R. Risesen, ADSC of first order transitions, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 667–668.
- S. R. Aubuchon, P. Chin and R. L. Hassel, A modulated DSCTM study of annealing and heat-set temperature, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 693–699.
- A. Boller, M. Ribeiro and B. Wunderlich, The analysis of first order transitions by TMDSC, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 706–713.
- W. J. Sichina, Examination of the use of dynamic DSC in the melting regions, Proc. 24th NATAS, September 10–13, 1995, San Francisco, CA, pp. 123–129.
- S. R. Sauerbrunn and L. C. Thomas, Modulated DSC: the melting transition, Proc. 23th NATAS, September 25–28, 1994, Toronto, Ontario, Canada, pp. 45–51.
- S. R. Sauerbrunn, P. S. Gill and C. L. Marozzi, Quantifying PEI/PC blends with modulated DSC, Proc. 22nd NATAS, September 19–22, 1993, Denver, Colorado, pp. 313–318.
- Y. P. Khanna, Crystallinity of poly(chlorotrifluoroethylene) by conventional and oscillatory DSC, Proc. 22nd NATAS, September 19–22, 1993, Denver, Colorado, pp. 391–393.
- M. Wulff, M. Alden and D. Q. M. Craig, An investigation into the critical surfactant concentration for solid solubility of hydrophobic drug in different polyethylene glycols, *Int. J. Pharm.*, 142 (1996) 189–198.
- J. Cattiaux, S. Derrough, L. Thomas and M. Chahinian, Principle and advantages of modulated DSC. Application to measurement of the initial crystallinity of polymers, *Calorim. Anal. Therm.*, (1995), 26 (26^{èmes} Journées de Calorimétrie et d'Analyse Thermique, 1995) 227–232.
- I. Harruna, K. B. Bota, T. Sanders and M. B. Polk, Oscillating differential scanning calorimetry of thermotropic copolyesters containing 1,4-cyclohexylenedimethylene spacer, *Polym. Prep. (Am. Chem. Soc., Div. Polym. Chem.)* 36 (1995) 361–362.
- I. Harruna, K. B. Bota and G. L. Collins, Thermal analysis of vectran fibers, *Polym. Prepr. (Am. Chem. Soc., Div. Polym. Chem.)*, 36 (1995) 359–360.
- I. I. Negulescu and W. H. Daly, Application of oscillating DSC to the detection of thermal transitions in poly(γ -alkyl- α , L-glutamate)s, *Polym. Prepr. (Am. Chem. Soc., Div. Polym. Chem.)*, 35 (1994) 441–442.
- J. E. K. Schawe and G. R. Strobl, Superheating effects during the melting of crystallites of syndiotactic polypropylene analysed by temperature-modulated differential scanning calorimetry, *Polymer*, 39 (1998) 3745–3751.
- F. Roussel and J. M. Buisine, Modulated differential scanning calorimetry. Transitions between monotropic and enantiotropic phases of a cholesteric liquid crystal, *J. Thermal Anal.*, 47 (1996) 715–725.

- F. Roussel and J. M. Buisine, Modulated differential scanning calorimetry analysis of transitions between monotropic and enantiotropic phases of a cholesteric liquid crystal. *Calorim. Anal. Therm.*, (1995), 26 (26èmes Journées de Calorimétrie et d'Analyse Thermique, 1995) 125–130.
- A. R. McGhie, J. E. Fischer, P. A. Heiney, P. W. Stephens, R. L. Cappelletti, D. A. Neumann, W. H. Mueller, H. Mohn and H. U. Meer, Phase transitions in solid C70: supercooling, metastable phases, and impurity effect, *Phys. Rev. B: Condens. Matter*, 49 (1994) 12614–12618.

Heat capacity

- B. Wunderlich, The heat capacity of polymers, *Thermochim. Acta*, 300 (1997) 43–65.
- T. Ozawa and K. Kanari, Heat capacity measurements by dynamic differential scanning calorimetry, *Thermochim. Acta*, 288 (1996) 39–51.
- I. Hatta and S. Muramatsu, High precision heat capacity measurements by dynamic differential scanning calorimetry, *Jpn. J. Appl. Phys.*, Part 2 35 (1996) (7A) L858–L860.
- A. M. Lammert, The heat capacity of aged maltose glasses measured by standard DSC and modulated DSC, Book of Abstracts, 213th ACS National Meeting, San Francisco, April 13–17 (1997), AGFD-028 Publisher: American Chemical Society, Washington, D.C.
- A. Zanier and H. W. Jaeckle, Heat capacity measurements of petroleum fuels by modulated DSC, *Thermochim. Acta*, 287 (1996) 203–212.
- M. Varma-Nair and B. Wunderlich, Non-isothermal heat capacities and chemical reactions using a modulated DSC, *J. Thermal Anal.*, 46 (1996) 879–892.
- J. E. Fischer, A. R. McGhie, J. K. Estrada, M. Haluska, H. Huzmany and H.-U. ter Meer, Heat capacity and the orientational transition in solid C60, *Phys. Rev. B: Condens. Matter* 53917 (1996) 11418–11424.
- A. Boller, Y. Jin and B. Wunderlich, Heat capacity measurement by modulated DSC at constant temperature. *J. Thermal Anal.*, 42 (1994) 307–330.
- G. W. H. Höhne, Remark on the interpretation of the imaginary part C'' of the complex heat capacity, *Thermochim. Acta*, 304/305 (1997) 121–123.
- B. Schenker and F. Stäger, Influence of the thermal conductivity on the C_p -determination by dynamic methods, *Thermochim. Acta*, 304/305 (1997) 219–228.
- K. Kanari and T. Ozawa, Simulation of temperature modulated DSC of temperature dependent heat capacity, *Thermochim. Acta*, 304/305 (1997) 201–207.
- B. Wunderlich, A. Boller, I. Okazaki and K. Ishikiriya, Heat-capacity determination by temperature-modulated DSC and its separation from transition effects, *Thermochim. Acta*, 304/305 (1997) 125–136.
- I. Alig, Ultrasonic relaxation and complex heat capacity, *Thermochim. Acta*, 304/305 (1997) 35–49.
- S. Weyer, A. Hensel, J. Korus, E. Donth and C. Schick, Broad band heat capacity spectroscopy in the glass-transition region of polystyrene, *Thermochim. Acta*, 304/305 (1997) 251–255.
- B. Wunderlich, Is complex heat capacity a useful output of temperature modulated calorimetry?, Book of Abstracts, 215th ACS National Meeting, Dallas, TX, March 29– April 2 (1998), PMSE-100, Volume 78, Publisher: American Chemical Society, Washington, D. C.
- M. Pyda, A. Boller, J. Grebowicz, H. Chuah and B. Wunderlich, Heat capacity of poly(trimethylene terephthalate), Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 87–94.
- G. Zhang and B. Wunderlich, Heat capacity of solid proteins by thermal analysis, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 540–547.

- B. J. Weddle, K. J. Kociba and P. K. Gallagher, Data reduction and alternative forms of data presentation for MT DSC quasi-isothermal temperature step specific heat data, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 631.
- G. B. McKenna and S. L. Simon, Interpretation of the dynamic heat capacity, Proc. 25th NATAS, September 7–9, 1997, McLean, Virginia, pp. 677–684.
- M. Varma-Nair, B. Wunderlich, J. J. Balogh and H. Aldrich, Evaluation of non-isothermal heat capacities and applications of modulated DSC, Proc. 23rd NATAS, September 25–28, 1994, Toronto, Ontario, Canada, pp. 26–32.
- W. J. Sichina, Accurate measurement of heat capacities using oscillating DSC, Proc. 23rd NATAS, September 25–28, 1994, Toronto, Ontario, Canada, pp. 64–71.
- Y. Jin, A. Boller and B. Wunderlich, Heat capacity measurement by modulated DSC at constant temperature, Proc. 22nd NATAS, September 19–22, 1993, Denver, Colorado, pp. 59–64.
- B. Schenker, G. Widmann and R. Riesen, Wave shapes in alternating DSC, *J. Thermal Anal.*, 49 (1997) 1097–1104.
- W. J. Sichina, Accurate measurement of heat capacities using oscillating differential scanning calorimetry, *Am. Lab. (Shelton, Conn.)*, 25 (1993) (12) 26–30.

Special topics

- D. J. Hourston, H. X. Zhang, M. Song, M. Pollock and A. Hammiche, Modulated differential scanning calorimetry - VII: interfacial macromolecular diffusion in core-shell latex particles, *Thermochim. Acta*, 294 (1997) 23–31.
- M. Song, H. M. Pollock, A. Hammiche, D. J. Hourston and M. Reading, Modulated differential scanning calorimetry. 8. Interface development between films of polyepichlorohydrin and poly(vinyl acetate), *Polymer*, 38 (1997) 503–507.
- D. J. Hourston, M. Song, A. Hammiche, H. M. Pollock and M. Reading, Modulated differential scanning calorimetry. 6. Thermal characterization of multicomponent polymers and interfaces, *Polymer*, 38 (1997) 1–7.
- A. Hammiche, M. Song, H. M. Pollock, D. J. Hourston and M. Reading, Phase separation of miscible blends: study by SThM and M-T DSC, *Polym. Mater. Sci. Eng.*, 75 (1996) 275–276.
- D. J. Hourston, F.-U. Schafer and J. S. Bates, Synthesis, characterization, and properties of interpenetrating polymer networks containing functionalized latex particles, *J. Appl. Polym. Sci.*, 60 (1996) 2409–2417.
- A. J. Berkovich, B. R. Young, J. H. Levy, S. J. Schmidt and A. Ray, Thermal characterization of Australian oil shales, *J. Thermal Anal.*, 49 (1997) 737–743.
- L. Granasy, S. Pekker and L. Forro, Thermodynamics of A₁C₆₀ (A=K, Rb, Cs) alkali fullerenes, *Fullerene Sci. Technol.*, 5 (1997) 325–342.
- S. R. Aubuchon and R. L. Blaine, Optimization of the thermal conductivity measurement by modulated DSC, *Therm. Conduct.*, 23 (1996) 66–71.
- C. M. Pistor, A. Yardiinci, J. K. Jasiak and S. I. Guceri, Thermal conductivity of composite materials, *Int. SAMPE Tech. Conf.* 28 (1996) (Technology Transfer in a Global Community) 564–573.
- S. R. Challa, S. Q. Wang and J. L. Koenig, Thermal induced phase separation of E7/PMMA PDLC system, *J. Thermal Anal.*, 45 (1995) 1297–1312.
- I. V. Mendenhall and S. F. Reid, Application of thermal analysis to development of gas generant formulations used to inflate automobile airbags, *Thermochim. Acta*, 272 (1996) 221–231.

- D. Chen and D. Dollimore, Sinusoidal temperature treatments in thermal analysis, *Thermochim. Acta*, 272 (1996) 75–85.
- S. M. Marcus and R. L. Blaine, Modulated differential scanning calorimetry: A new method for thermal conductivity of polymers, glasses and ceramics, *Therm. Conduct.*, 22 (1994) 826–833.
- M. Reading, D. J. Hourston and M. Song, Modulated temperature and microthermal methods, *Book of Abstracts 215th ACS National Meeting*, Dallas, TX, March 29–April 2 (1998), PMSE-122, Volume. 78, Publisher: American Chemical Society, Washington, D.C.
- S.-C. Chiu, T. K. Kwei and E. M. Pearce, The measurement of phase separation behavior of poly(*n*-hexyl methacrylate)/poly(styrene-co-vinylphenol) blends in temperature modulated differential scanning calorimetry, *Book of Abstracts 215th ACS National Meeting*, Dallas, TX, March 29–April 2 (1998), PMSE-125, Volume, 78, Publisher: American Chemical Society, Washington, D.C.
- M. Song, D. J. Hourston, H. M. Pollock, F.-U. Schäfer and A. Hammiche, Modulated differential scanning calorimetry: XI. A characterisation method for interpenetrating polymer networks, *Thermochim. Acta*, 304/305 (1997) 335–346.
- M. Song, D. J. Hourston, F.-U. Schäfer, H. M. Pollock and A. Hammiche, Modulated differential scanning calorimetry: XVI. Degree of mixing in interpenetrating polymer networks, *Thermochim. Acta*, 315 (1998) 25–32.
- D. J. Hourston, M. Song, F.-U. Schäfer and M. Reading, Analysis of the morphology of interpenetrating polymer networks by means of modulated-temperature differential scanning calorimetry, *Proc. 25th NATAS*, September 7–9, 1997, McLean, Virginia, pp. 669–676.
- S. R. Aubuchon and R. L. Blaine, Direct measurement of thermal conductivity using modulated DSC, *Proc. 24th NATAS*, September 10–13, 1995, San Francisco, CA, pp. 142–147.
- D. Chen and D. Dollimore, Sinusoidal temperature treatments in thermal analysis, *Proc. 23th NATAS*, September 25–28, 1994, Toronto, Ontario, Canada, pp. 14–19.
- S. M. Marcus and R. L. Blaine, Thermal conductivity of polymers, glasses and ceramics by modulated DSC, *Proc. 2nd NATAS*, September 19–22, 1993, Denver, Colorado, pp. 102–108.
- A. Thakur, A. K. Banthia and B. R. Maiti, Studies on the kinetics of free-radical bulk polymerization of multifunctional acrylates by dynamic differential scanning calorimetry, *J. Appl. Polym. Sci.*, 58 (1995) 959–966.
- A. Cesaro, L. Navarini and L. Pepi, A modulated DSC analysis of microbial biocompatible polyesters, *Thermochim. Acta*, 227 (1993) 157–166.

Instrumentation

- A. Boller, I. Okazaki, K. Ishikiriyama, G. Zhang and B. Wunderlich, Determination of cell asymmetry in temperature modulated DSC, *J. Thermal Anal.*, 49 (1997) 1081–1088.
- Y. Saruyama, Application of light heating dynamic DSC to polymeric materials, *J. Thermal Anal.*, 49 (1997) 139–142.
- Y. Saruyama, Development of light heating dynamic DSC. II. Determination of complex calibration constants, *Thermochim. Acta*, 282/283 (1996) 157–163.
- M. Nishikawa and Y. Saruyama, Development of the light heating dynamic DSC, *Thermochim. Acta*, 267 (1995) 75–81.
- I. Hatta, AC calorimetric aspect of dynamic differential scanning calorimetry, *Thermochim. Acta*, 272 (1996) 49–52.
- Y. Saruyama, Temperature distribution in the sample of the dynamic DSC undergoing the first order phase transition, *Netsu Sokutei*, 22 (1995) 190–192.

- S. R. Aubuchon and P. S. Gill, The utility of phase correction in modulated DSC, *J. Thermal Anal.*, 49 (1997) 1039–1044.
- M. Reading, Method and apparatus for gas flow modulated differential scanning calorimetry, *Eur. Pat. Appl.*, 9 pp. EP-747694 A2 961211.
- J. A. Foreman and R. L. Blaine, Optimization of the modulated DSC technique for plastics, *Ann. Tech. Conf.-Soc. Plast. Eng.*, (1995) 53rd, 2499–2503.
- Y. Saruyama, Melting transition of polyethylene studied by light-modulated calorimetry, *Thermochim. Acta*, 304/305 (1997) 171–178.
- A. A. Minakov, Low-temperature AC-microcalorimetry: Possibilities and limitations, *Thermochim. Acta*, 304/305 (1997) 165–170.
- K. Fma and H. Yao, Some aspects of recent improvements of temperature-modulated calorimeter, *Thermochim. Acta*, 304/305 (1997) 157–163.
- Y.-H. Jeong, Progress in experimental techniques for dynamic calorimetry, *Thermochim. Acta*, 304/305 (1997) 67–98.
- A. Hensel and C. Schick, Temperature calibration of temperature-modulated differential scanning calorimetry, *Thermochim. Acta*, 304/305 (1997) 229–237.
- F. Cser, F. Rasoul and E. Kosior, Modulated differential scanning calorimetry. The effect of experimental variables, *J. Thermal Anal.*, 50 (1997) 727–744.
- Y. Saruyama, Development of a new type of light modulated DSC, *Proc. 25th NATAS*, September 7–9, 1997, McLean, Virginia, pp. 700–704.
- Y. Saruyama, Development of the light heating dynamic DSC, *Proc. 23rd NATAS*, September 25–28, 1994, Toronto, Ontario, Canada, pp. 20–25.
- S. R. Sauerbrunn, P. S. Gill and J. A. Foreman, Modulated DSC: the effect of period, *Proc. 23rd NATAS*, September 25–28, 1994, Toronto, Ontario, Canada, pp. 51–56.
- S. R. Sauerbrunn and R. L. Blaine, Modulated DSC: the effect of amplitude, *Proc. 23rd NATAS*, September 25–28, 1994, Toronto, Ontario, Canada, pp. 57–64.
- J. E. K. Schawe, Modulated temperature DSC measurements: the influence of the experimental conditions, *Thermochim. Acta*, 271 (1996) 127–140.
- J. E. K. Schawe, A comparison of different evaluation methods in modulated temperature DSC, *Thermochim. Acta*, 260 (1995) 1–16.

Thermosets

- G. van Assche, A. van Hemelrijck and B. van Mele, Modulated temperature differential scanning calorimetry. Considerations for a quantitative study of thermosetting systems, *J. Thermal Anal.*, 49 (1997) (1) 443–447.
- A. van Hemelrijck and B. van Mele, Modulated temperature differential scanning calorimetry. Characterization of curing systems by TTT and CHT diagrams, *J. Thermal Anal.*, 49 (1997) 437–442.
- G. Maistros, Q. P. V. Fontana, D. Attwood and J. S. Hudd, Use of modulated differential scanning calorimetry to observe vitrification during epoxy resin cure, *J. Mater. Sci. Lett.*, 16 (1997) 273–275.
- Q. Wang, T. He, P. Xia, T. Chen and B. Huang, Cure processing modeling and cure cycle simulation of epoxy-terminated poly(phenylene ether ketone). I. DSC characterization of curing reaction.
- S. Tasumiya, K. Yokokawa and K. Miki, A dynamic DSC study of the curing process of epoxy resin, *J. Thermal Anal.*, 49 (1997) 123–129.
- P. Simon, A. Kucma and S. Prekop, Kinetic analysis of vulcanization of rubber compounds by differential scanning calorimetry, *Piasty Kauc.*, 34 (1997) 103–106.

- D. S. Kim and B. T. Hong, Cure behavior and thermal properties of dicyanate resin, *Pollimo*, 21 (1997) 252–261.
- M.-J. Shim and S.-W. Kim, Cure reaction and mechanical properties of DGEBA/MDA/nitrile system, *Mater. Chem. Phys.*, 47 (1997) 198–202.
- P. B. Zetterlund and A. F. Johnson, A new method for the determination of the Arrhenius constants for the cure process of unsaturated polyester resins based on a mechanistic model, *Thermochim. Acta*, 289 (1996) 209–221.
- M.-S. Lin and G.-A. Chium, Curing behavior and mechanical behavior of fully and semi-interpenetrating polymer networks based on polyurethane and acrylic, *J. Polym. Res.*, 3 (1996) 165–171.
- S.-T. Lin and S. K. Huang, Study of curing kinetics of siloxane-modified DGEBA epoxy-resins, *J. Appl. Polym. Sci.*, 62 (1996) 1641–1649.
- S. J. Tuman, D. Chamberlain, K. M. Scholsky and M. D. Soucek, Differential scanning calorimetry study of linseed oil cured with metal catalysts, *Prog. Org. Coat*, 28 (1996) 251–258.
- R. Chandra, L. Rajabi and R. K. Soni, The effect of bismaleimide resin on curing kinetics of epoxy-amine thermosets, *J. Appl. Polym. Sci.*, 62 (1996) 661–671.
- M. Opalicki, J. M. Kenny and L. Nicolais, Cure kinetics of neat and carbon-fiber reinforced TGDDM/DDS epoxy systems, *J. Appl. Polym. Sci.*, 61 (1996) 1025–1037.
- T. Yoon, B. S. Kim, J. Kim and D. S. Lee, Cure behavior of high performance epoxy/polysulfone blends (II): Dynamic DSC analysis, *Pollimo*, 20 (1996) 412–418.
- K. S. Siddaramaiah, Jagadeesh and G. Prabhakara, Cure kinetics of epoxy formulations with diaminodiphenyl methane, *Indian J. Eng. Mater. Sci.*, 3 (1996) 114–118.
- M. Rong and H. Zeng, Polycarbonate/epoxy semi-interpenetrating polymer network: 1. Preparation, interaction and curing behavior, *Polymer*, 37 (1996) 2525–2531.
- J.-Y. Lee, I.-S. Chun, M.-J. Shim and S.-W. Kim, Cure kinetics of natural zeolite/epoxy composites, *Kongop Hwahak*, 7 (1996) 387–392.
- J. A. McGowen and L. J. Mathias, Cationic cure of DGEBA resins initiated by benzyl sulfonium salts, *Book of Abstracts*, 211th ACS National Meeting, New Orleans, LA, March 24–28 (1996), PMSE-014.
- W. Mormann and J. G. Zimmermann, Liquid crystalline thermosets through cyclotrimerization of diaromatic dicyanates, *Macromolecules*, 29 (1996) 1105–1109.
- M.-S. Lin and S.-T. Lee, Curing behavior of fully and semi-interpenetrating polymer networks based on epoxy and acrylics, *Polymer*, 36 (1995) 4567–4572.
- Z.-W. Kong, S. Ye and D.-X. Wang, Characteristics of curing reaction of maleopimaric acid-type epoxy resin, *Reguxing Shuzhi*, 10 (1995) 48–53.
- J.-Y. Chang and J.-L. Hong, Curing kinetics of cyanated poly(ether sulfones) of different molecular weights, *Macromol. Chem. Phys.*, 196 (1995) 3753–3763.
- Y.-H. Wang Y.-L. Hong and J.-L. Hong, Cure kinetics of a flexible aromatic dicyanate with Schiff base structure, *J. Appl. Polym. Sci.*, 58 (1995) 1585–1592.
- D. S. Kim, M. J. Han and J. R. Lee, Cure behavior and properties of an epoxy resin modified with a bismaleimide resin, *Polym. Eng. Sci.*, 35 (1995) 1353–1358.
- I.-S. Chun, M.-J. Shim and S.-W. Kim, Cure kinetics for modified epoxy resin system: Barrett method and integral method approaches, *Kongop Hwahak*, 6 (1995) 35–41.
- H. Kim, Y. S. Eom, K.-M. Chung, K. J. Ahn and K. Char, A study on curing process of epoxy/glass fiber prepregs *Pollimo*, 19 (1995) 265–273.
- A. Padma, R. M. V. G. K. Rao, C. Subramaniam and G. Nagendrappa, Cure characterization of triglycidyl epoxy/aromatic amine systems, *J. Appl. Polym. Sci.*, 57 (1995) 401–412.
- J. A. Reina, A. Serra, A. Mantecon and V. Cadiz, Crosslinking study of polyethers containing pendent double bonds, *J. Polym. Sci., Part A: Polym. Chem.*, 33 (1995) 1665–1671.

- S. B. Sastri, J. P. Armistead and T. M. Keller, Cure kinetics of a multisubstituted acetylenic monomer, *Polymer*, 36 (1995) 1449–1454.
- M.-C. Lu and J.-L. Hong, Cure kinetics and gravimetric analysis of a flexible aromatic dicyanate, cyanated phenylene sebacate oligomer, *Polymer*, 35 (1994) 2822–2827.
- J.-L. Hong, C.-K. Wang and R.-H. Lin, Cure kinetics of different molar ratios of 4,4'-bismaleimidediphenylmethane and bisphenol A dicyanate, *J. Appl. Polym. Sci.*, 53 (1994) 102–112.
- D. S. Kim and S. C. Kim, Rubber modified epoxy resin. I: Cure kinetics and chemorheology, *Polym. Eng. Sci.*, 34 (1994) 625–631.
- Y. J. Lee, K. J. Lee, D. S. Kim, H. Y. Yoo and J. R. Lee, Cure behavior and thermal stability of epoxy resin-phenol resin mixtures, *Pollimo*, 18 (1994) 206–211.
- K. Urayama, Analysis of epoxy resin curing by measurement of MDSC and rheology, *Setchaku no Gijyutsu*, 16 (1996) 31–35.
- F. E. Arnold and S. Thoman, B-staging of toughened epoxy composites, *Int. SAMPE Tech. Conf.*, 28 (1996), (Technology in a Global Community) 1290–1299.
- G. van Assche, A. van Hemerijck, H. Rahier and B. van Mele, Modulated differential scanning calorimetry: non-isothermal cure, vitrification and devitrification of thermosetting systems, *Thermochim. Acta*, 286 (1996) 209–224.
- G. van Assche, A. van Hemerijck, H. Rahier and B. van Mele, Modulated differential scanning calorimetry: isothermal cure and vitrification of thermosetting systems, *Thermochim. Acta*, 268 (1996) 121–142.
- H. Rahier, B. van Mele, and J. Wastiels, Low-temperature synthesized aluminosilicate glasses. Part II. Rheological transformations during low-temperature cure and high-temperature properties of a model compound, *J. Mater. Sci.*, 31 (1996) 80–85.
- M. Wuebbenhorst, J. van Turnhout and L. Alili, Characterization of the cure of epoxy by pyroelectric calorimetry, *Ferroelectrics*, 165 (1995) 153–169.
- F. F. Saremi and S. Sauerbrunn, Characterization of E-761 epoxy via thermal analysis techniques, *Int. SAMPE Symp. Exhib.*, 39 (1994) (Moving Forward with 50 Years of Leadership) 2530–2543.
- G. van Assche, A. van Hemerijck, H. Rahier and B. van Mele, Modulated temperature differential scanning calorimetry: Cure, vitrification, and devitrification of thermosetting systems, *Thermochim. Acta*, 304/305 (1997) 317–334.
- I. S. Adhietty, P. K. Mukerji and R. P. Padmanabhan, MDSC for chip encapsulants, *Proc. 22nd NATAS*, September 19–22, 1993, Denver, Colorado, pp. 326–331.

Review papers

- L. Judovits, Introduction to MDSC, theory and application, *NATAS Notes*, 29 (1997) 31–34.
- P. J. Paniez, S. Brun and S. Derrough, *Proc. SPIE-Int. Soc. Opt. Eng.*, 3049 (1997) (Advances in Resist Technology and Processing XIV) 168–177.
- P. Conde and J. Manuel, Modulated differential scanning calorimetry. A further step in the study of thermal properties of polymers, *Rev. Plast. Mod.*, 73 (1997) 26–31.
- S. Cerizza, Modern power compensation DSC, *Boll. Chim. Farm.*, 135 (1996) 570–574.
- M. P. DiVito, R. B. Cassel, M. Margulies and S. Goodkowsky, Dynamic differential scanning calorimetry, *Am. Lab. (Shelton, Conn.)* 27 (1995) 28, 30–32, 34, 36–37.
- D. W. Nehrkorn and L. H. MacPherson, Modulated DSC: A complementary thermal analysis technique, *Book of Abstracts*, 213th ACS National Meeting, San Francisco, April 13–17 (1997), TECH-003 Publisher: American Chemical Society, Washington, D.C.

- J. Cattoaux, S. Derrough, L. Thomas and M. Chahinian, Principle and advantage of modulated DSC. Application to measurement of the initial crystallinity of polymers, *Calorim. Anal. Therm.*, (1995), 26 (26èmes Journées de calorimétrie et d'Analyse Thermique, 1995) 227–232.
- J. P. Harmon, P. Bertolucci and H. Gao, Thermal analysis of optical polymers: DMA, MDSC and DEA, *Polym. Prep. (Am. Chem. Soc., Div. Polym. Chem.)*, 36 (1995) 225–226.
- M. Reading, K. Jones and R. Wilson, Modulated differential scanning calorimetry, *Netsu Sokutei*, 22 (1995) 83–84.
- D. Q. M. Craig, A review of thermal methods used for the analysis of the crystal form, solution thermodynamics and glass transition behavior of polyethylene glycols, *Thermochim. Acta*, 248 (1995) 189–203.
- D. R. Kamm, B. S. Crowe and M. Reading, Modulated differential scanning calorimetry, *Proc. Natl. Symp. Thermal Anal.*, 9th (1993), 19–26. Editor: Ravindran, P. V. Publisher: Indian Therm. Anal. Soc., Bombay, India
- N. Buckman, Modulated DSC: the newest innovation in thermal analysis, *Chem. Aust.*, 60 (1993) 666–667.
- M. Reading, A. Luget and R. Wilson, Modulated differential scanning calorimetry, *Thermochim. Acta*, 238 (1994) 295–307.
- P. Gallagher, Thermal analysis, *Adv. Anal. Geochem.*, 1 (1993) 211–257.
- S. Sauerbrunn and P. Gill, A technique for differential scanning calorimetry, *Am. Lab. (Shelton, Conn.)*, 25 (1993) 56–58.
- M. Reading, D. Elliott and V. L. Hill, A new approach to the calorimetric investigation of physical and chemical transitions, *J. Thermal Anal.*, 40 (1993) 949–955.
- A. F. Barnes, M. J. Hardy and T. J. Lever, A review of the applications of thermal methods within the pharmaceutical industry, *J. Thermal Anal.*, 40 (1993) 499–509.
- M. Reading, Modulated differential scanning calorimetry – a new way forward in materials characterization, *Trends Polym. Sci.*, 1 (1993) 248–253.
- P. S. Gill, S. r. Sauerbrunn and M. Reading, Modulated differential scanning calorimetry, *J. Thermal Anal.*, 40 (1993) 931–939.
- S. Sauerbrunn, B. Crowe and M. Reading, Modulated differential scanning calorimetry, *Am. Lab. (Shelton, Conn.)*, (1992) 24–12, 44, 46–47.
- Y.-H. Jeong, Progress in experimental techniques for dynamic calorimetry, *Thermochim. Acta*, 304/305 (1997) 67–98.
- K. J. Jones, I. Kinshott, M. Reading, A. A. Lacey, C. Nikolopoulos and H. M. Pollock, The origin and interpretation of the signals of MTDSC, *Thermochim. Acta*, 304/305 (1997) 187–199.
- A. Boller, Modulated differential scanning calorimetry (MDSC).
<http://funnelweb.utcc.utk.edu/~athas/reports/report95/rep95md.html>
- D. J. Hourston, M. Song, H. M. Pollock and A. Hammiche, Applications of modulated temperature differential scanning calorimetry to a range of problems in polymer science, *Proc. 24th NATAS*, September 10–13, 1995, San Francisco, CA, pp. 109–113.
- M. Reading, D. J. Hourston, M. Song, H. M. Pollock and A. Hammiche, Thermal analysis of the 21st century, *Am. Lab. (Shelton, Conn.)*, 30 (1998) 13–17.
- M. Reading, Modulated temperature DSC: where are we now?, *Proc. 25th NATAS*, September 7–9, 1997, McLean, Virginia, p. 622.
- R. Riesen and G. Widman, ADSC: applications of the alternating heating rate DSC, *Proc. 24th NATAS*, September 10–13, 1995, San Francisco, CA, pp. 115–122.
- S. F. Goodkowsky, R. B. Cassel and M. P. DiVito, A unique approach to dynamic thermal analysis – dynamic differential scanning calorimetry, *Proc. 24th NATAS*, September 10–13, 1995, San Francisco, CA, pp. 130–135.

- B. Wunderlich and A. Boller, Modulated differential scanning calorimetry capabilities and limits. Proc. 24th NATAS, September 10–13, 1995, San Francisco, CA, pp. 136–141.
- B. Braggs and E. Barone, The characterization of pharmaceutical polymers by modulated differential scanning calorimetry, Proc. 24th NATAS, September 10–13, 1995, San Francisco, CA, pp. 548–553.
- M. Reading, R. Wilson and H. M. Pollock, Modulated differential scanning calorimetry: theory practice and applications, Proc. 23rd NATAS, September 25–28, 1994, Toronto, Ontario, Canada, pp. 2–11.
- I. Hatta, Feature of dynamic DSC considered from the standpoint of AC calorimetry, Proc. 23rd NATAS, September 25–28, 1994, Toronto, Ontario, Canada, pp. 32–37.
- W. J. Sichina, Oscillating DSC (ODSC) as problem solving tool, Proc. 23rd NATAS, September 25–28, 1994, Toronto, Ontario, Canada, pp. 38–44.
- W. J. Sichina, N. Nakamura and Y. Teramoto, Oscillating differential scanning calorimetry, Proc. 22nd NATAS, September 19–22, 1993, Denver, Colorado, pp. 260–268.
- P. S. Gill, S. R. Sauerbrunn and M. Reading, Modulated differential scanning calorimetry, *J. Thermal Anal.*, 40 (1993) 931–939.
- M. Reading, D. Elliott and V. L. Hill, A new approach to the calorimetric investigation of physical and chemical transitions, *J. Thermal Anal.*, 40 (1993) 949–955.
- B. Wunderlich, Learning about calorimetry, *J. Thermal Anal.*, 49 (1997) 7–16.
- M. Reading, S. Sauerbrunn and B. Crowe, Modulated differential scanning calorimetry, Proc. 21st NATAS, September 13–16, Atlanta, GA, pp. 137–144.
- M. Reading, D. Elliott and V. Hill, Some aspects of the theory and practice of modulated differential scanning calorimetry, Proc. 21st NATAS, September 13–16, Atlanta, GA, pp. 145–150.

Pharmaceuticals and food science

- P. G. Royall, D. Q. M. Craig and C. Doherty, Characterization of the glass transition of an amorphous drug using modulated DSC, *Pharm. Res.*, 15 (1998) 1117–1121.
- N. J. Coleman and D. Q. M. Craig, Modulated temperature differential scanning calorimetry: a novel approach to pharmaceutical thermal analysis, *Int. J. Pharm.*, 135 (1996) 13–29.
- R. O. William, M. Sriwongjanya and J. Liu, An in vitro method to investigate food effects on drug release from film-coated beads, *Pharm. Dev. Technol.*, 2 (1997) 1–9.
- M. Wulff and M. Alden, Phase equilibria in drug-polymer-surfactant systems, *Thermochim. Acta*, 256 (1995) 151–165.
- I. M. Vitez, A. W. Newman, P. A. Cortina and G. Young, Evaluation of pharmaceutical polymorph issues using modulated differential scanning calorimetry, Proc. 23rd NATAS, September 25–28, 1994, Toronto, Ontario, Canada, pp. 626–632.
- M. Alden and A. Magnusson, Effect of temperature history on the freeze-thawing process and activity of LDH formulations, *Pharm. Res.*, 14 (1997) 426–430.
- M. Wulff and M. Alden, Thermal analysis in pharmaceutical systems using oscillating differential scanning calorimetry, *World Meet. Pharm. Biopharm. Pharm. Technol.*, 1st (1995) 70–71, Publisher: APGI, Chatenay Malabry, Fr.
- G. M. Wang and A. D. J. Haymet, Trehalose and other sugar solutions at low temperature: modulated differential scanning calorimetry (MDSC), *J. Phys. Chem. B*, 102 (1998) 5341–5347.

Inorganic and organic chemistry

- Y. Li, S. C. Ng, Z. P. Lu, Y. P. Feng and K. Lu, Melting and solidification of Pb nanoparticles embedded in an Al matrix as studied by temperature-modulated differential scanning calorimetry, *Philos. Mag. Lett.*, 78 (1998) 37–44.

- K. Gyoryova, V. Balek, B. H. Behrens, A. Matuschek and A. Kettrup, Thermal properties of zinc butyrate complex compounds. II. Caffeine, nicotinamide and theobromine, *J. Thermal Anal.*, 48 (1997) 1263–1271.
- Y.-S. Duh, C.-S. Kao, C. Lee and S. W. Yu, Runaway hazard assessment of cumene hydroperoxide from the cumene oxidation process, *Process Saf. Environ. Prot.*, 75(B2) (1997) 73–80.
- M. Ghaemy and M. H. Khandani, Study of polymerization mechanism and kinetics of DGEBA with BF_3 -amine complexes using FT-IR and dynamic DSC, *Iran. Polym. J.*, 6 (1997) 5–17.
- J. Zhu, M. T. Clavaguera-Mora and N. Clavaguera, Relaxation process of Fe(CuNb)SiB amorphous alloys investigated by dynamic calorimetry, *Appl. Phys. Lett.*, 70 (1997) 1709–1711.
- K. J. Kociba and P. K. Gallagher, A study of calcium oxalate monohydrate using dynamic differential scanning calorimetry and other thermoanalytical techniques, *Thermochim. Acta*, 282/283 (1996) 277–296.
- K. Gyoryova, V. Balek and J. Kovarova, Thermal properties of zinc butyrate complex compounds. Part I: urea and thiourea ligands, *Thermochim. Acta*, 269/270 (1995) 425–432.
- S. Chevalier, C. Perut, L. Billon and M. Grevin, Antioxidant selection methodology for hydroxy-terminated polybutadiene-type solid propellants, *Int. Ann. Conf. ICT (1994)*, 25th (Energetic Materials-Analysis, Characterization and Test Techniques), 12/1–12/4.
- M. Botoshansky, F. H. Herbstein and M. Kapon, Crystallography of metal picrates. II. Crystal structure of yellow thallium (I) picrate; relations among various metal (I) picrate phases, *Acta Crystallogr., Sect. B: Struct. Sci.*, (1994) B50(5) 589–596.
- C. Seeger and P. L. Ryder, Kinetics of the crystallization of amorphous Ti–Ni and Ti–Ni–Si alloys, *Mater. Sci. Eng., A (1994)* A170–A180, 641–644.
- K. A. Q. O'Reilly and B. Cantor, Cyclic differential scanning calorimetry and the melting and solidification of pure metals, *Proc. R. Soc. London, Ser. A (1996)*, 452 (1952) 2141–2160.
- C. Tomasi, P. Mustarelli, E. Quartarone and R. Pepi, MDSC and DSC studies on sol-gel lithium triborate glass ceramics: a comparison, *Thermochim. Acta*, 304/305 (1997) 353–358.
- K. J. Kociba and P. K. Gallagher, A novel approach to the determination of solid-state reaction kinetics using modulated-temperature DSC, *Proc. 25th NATAS*, September 7–9, 1997, McLean, Virginia, p. 632.
- K. J. Kociba and P. K. Gallagher, A study of oxalates by MDSC yields unexpected transitions, *Proc. 23rd NATAS*, September 25–28, 1994, Toronto, Ontario, Canada, p. 12.
- K. J. Kociba and P. K. Gallagher, Thin film behavior characterized by MDSC, *Proc. 23rd NATAS*, September 25–28, 1994, Toronto, Ontario, Canada, p. 13.
- S. R. Aubuchon, J. A. Foreman and C. J. Lundgren, Investigation of the Curie-transition via modulated DSC, *Proc. 24th NATAS*, September 10–13, 1995, San Francisco, CA, pp. 148–153.
- I. M. Vitez, A. W. Newman, P. A. Cortina and G. Young, Evaluation of pharmaceutical polymorph issues using modulated differential scanning calorimetry, *Proc. 23rd NATAS*, September 25–28, 1994, Toronto, Ontario, Canada, pp. 626–632.
- M. Alden, M. Wulff and S. Herdidijs, Influence of selected variables on heat of fusion determinations by oscillating DSC, *Thermochim. Acta*, 265 (1995) 89–102.
- D. De Filippo, P. Deplano, F. Devillanova and E. F. Trogu, Diselenocarbamates with square-planar stereochemistry, *Inorg. Chim. Acta*, 17 (1996) 199–203.

Degradation or decomposition

- I. Simkovic, K. Balog and K. Csomorova, Thermal degradation and thermooxidation of *o*-acetyl-(4-*o*-methyl-*D*-glucurono)-*D*-xylan and related derivatives, *Holzforschung*, 49 (1995) 512–516.
- L. Haellidahl and B. Oloffson, Thermal analysis studies using oscillating DSC to determine changes in *LD* ethene/butene copolymer induced by gamma radiation treatment, *Thermochem. Acta*, 256 (1995) (1) 137–149.