

IUPAC Working Party IV.2.1 “Structure and Properties of Commercial Polymers” – History, Output, and Future Prospects

D. R. Moore and H. M. Laun

(August 28, 2003)

Abstract

IUPAC Working Party IV.2.1 is part of the Macromolecular Division (Division IV) of the International Union of Pure and Applied Chemistry (IUPAC). The Working Party has existed since 1963, first as part of the IUPAC Commission on Macromolecules and then, since 1965, as part of the Macromolecular Division. The aims of the Working Party have been to collaborate with an international network of scientists whose interests lie within the broad field of the structure and properties of commercial polymers. It has held 70 meetings in the period 1963 to January 2003 and has published more than 80 papers in the scientific literature.

The drivers of the Working Party have been its members and their motivation to obtain value (to them and their businesses) from participation in the group. If this is achieved then their businesses fund their participation. This has been in process for 40 years, during which time many different and changing economic climates have existed.

The purpose of this article is to examine several aspects of the group including its activities and achievements, its motivation and finally to comment on its future role.

1 Introduction

IUPAC Working Party IV.2.1 “Structure and Properties of Commercial Polymers” is part of the Macromolecular Division (Division IV) of the International Union of Pure and Applied Chemistry (IUPAC). The Working Party has existed since 1963, first as part of the IUPAC Commission on Macromolecules and then, since 1965, as part of the Macromolecular Division. From 1973 to 1999, it operated within the Commission on Characterisation and Properties (IV.2) of Division IV.

Participants of the first meeting at University College, London, in July 1963 were J. W. Barrett and S. Baxter of Monsanto Chemicals Ltd., R. F. Boyer of DOW Chemical Company, A. Rodeyns of Solvay & Cie, J. Heijboer and J. W. Brecht of TNO Delft, and I. Franta of Technická Prague. The scientists from polymer producing companies being competitors on the market, agreed that cooperation was required for scientifically sound methods to determine the physical and technological properties of thermoplastics and to relate them to the structure of such products offered commercially. Consequently, this new working party was named “IUPAC Working Party on the Relationships of Performance Characteristics to Basic Parameters of Polymers”. Two of the first topics to be dealt with were “Torsion pendulum measurements” and “Rheological studies (on poly(styrene))”. In 1972, stressing the commercial aspects, the Working Party was renamed to include as key activity “Structure and Properties of Commercial Polymers”.

Co-operation between competing companies has been successful over the years only with the agreement that information concerning reaction procedures for polymerising the products under investigation is kept as secrets of the companies offering such materials for testing within the Working Party. Today, the members of the Working Party form an international network of scientists whose interests lie within the broad field of the structure and properties of commercial polymers. The use of the adjective “commercial” implies an industrial relevance to the group. The operation within IUPAC implies a global, harmonious and focused set of activities usually best conducted on a project basis in order to have defined targets, starting points and end-points.

A simple description of the activities and output of Working Party IV.2.1 provides a useful focus for a study its history and future prospects:

- (i) It started in 1963 and still operates
- (ii) Its current membership is 66 scientists from 17 different countries
- (iii) It has a balanced membership from industry, and universities and institutions
- (iv) All members are active
- (v) It has held 69 meetings including those scheduled for 2003
(**Tables 1 and 2** summarise the various locations that have been used for the Working Party meetings over the years.)
- (vi) It has had only 6 chairmen (and 5 secretaries)
- (vii) It has published more than 80 scientific papers.

This description represents a successful track record. However, a group that has endured for 40 years gets tainted with words like “precious”, “closed shop”, “unchanging” and even “moribund”! There is even the view that groups that have

apparent external management should be modified because it has become unfashionable not to inject new directions or new aims. Consequently, the purpose of this article is to examine several aspects of the group and in particular:

- (i) Its activities and achievements¹.
- (ii) Its motivation.
- (iii) To explore whether it has evolved over the years to become something quite different from that which it started out as.
- (iv) To comment on what could be its future role.

In order to analyse the performance of the Working Party, it is helpful to learn something of its format and mode of operation. One of its former chairmen P.L. Clegg reviewed [18] this in 1983 and much of what he discussed remains applicable. The group meets at least once per year. It defines projects on which at least a significant part of the membership agrees to work on and to commit resources. Its projects have particular scientific targets and have been mainly experimental in nature. Participation in a project is voluntary and can entail between 5 and 20 scientists from different laboratories throughout the world. Projects are co-ordinated by one or two project leaders who guide projects to publications (usually in the IUPAC journal *Pure and Applied Chemistry*). Projects need about 4-6 years to produce the first publication but sometimes can take longer to complete. New members can be drafted into the Working Party in order to provide expertise for a particular project. For a person to maintain membership of the Working Party it is necessary that they participate actively in at least one project and attend meetings at least every two years. Also, the projects conducted by the Working Party have been funded by the participants and in turn by their organisations. This indicates a self-appraising value-index for the work.

Although the Working Party sits within IUPAC, it is largely self-governing and elects in its own executive officers. To these organisational characteristics, it should be added that its members enjoy the opportunity of mixing and working with like-minded scientists, even though they often come from competitive organisations. Co-operation is made possible by ensuring that the choice of project does not restrict the interactions between scientists from different organisations when they work together.

With this background, it is now possible to examine the aspects of the Group introduced earlier.

2 Activities and Achievements

The Early Years (1963–ca.1980)

(See Table 1 for the list of meetings held in this period)

At the first meeting of the Working Party in 1963 there were only 7 scientists in attendance. However, in the years that followed the numbers of participating scientists, companies and institutions grew quickly. The first publication prepared by

¹ A full list of publications emanating from the Working Party is given in the references.

T.T. Jones [1] “The Relationship of Performance Characteristics to Basic Parameters of Polymers. I. A Collaborative Study of Polystyrene Using Torsion Pendulum and Impact Methods” was published in 1968. Six laboratories contributed to this publication: BASF, DOW, Monsanto, Solvay, TNO and Technická Prague.

The second publication [2] was also devoted to mechanical problems, whereas the first publication on the collaborative study of polystyrene and polyethylene melts [3] was published by J.L.S. Wales in 1969. Contributing laboratories to this publication were Monsanto, Péchiney-Saint-Gobain, Solvay and TNO.

As in [2], poly(vinyl chloride) (PVC) continued to be one of the polymers in the focus of the Working Party with regard to its mechanical [5,8,10] and capillary-flow [6] properties. An additional paper [4], on the influence of molecular relaxation on mechanical properties of PVC explicitly states its motivation from discussions within the Working Party. This contribution was published before the finalisation of the project with approval by the Working Party. The effect of molecular orientation on mechanical properties of rubber-modified polystyrene was published by Retting [9].

In these early years, the participating scientists had a considerable arsenal of mechanical and rheological methods of measurement available to them; but there was always much discussion and work devoted to the experimental problems involved in finding the most reliable test performance. In general, the participants in the Working Party had an excellent appreciation of the structure-property science of polymers. Most participating scientists were from the plastics industry from the U.S.A. and Europe, but with passing years they were more and more supplemented by scientists from academia worldwide, even from the previous Soviet Union (e.g., Prof. Vinogradov, Moscow). In addition to the early work of the Working Party on polyolefins, PVC and polystyrene, there were also some excursions into polypropylene film [15,16].

The issues that concerned the Working Party in the first 10 years were about how to relate their mechanical and rheological measurements to the practical world of plastics processing and performance. A number of projects were devoted to this theme. J. Meissner [7] led a project where the rheological properties of three low-density polyethylene samples were related to their tubular-film-blowing characteristics. The significance of this study concerned the similarity of most rheological properties of the three materials in simple shear and capillary flow but the significant differences in their extensional flow properties². From this work, the importance of extensional-flow testing became obvious and motivated further efforts in the development of extensional rheometers. An additional study led by H.H. Winter [19] on a high and low density polyethylene continued this theme.

The processing of PVC was studied in terms of attempts to define the basic flow “structures” and to relate these to rheological properties. In this project [11], led by F.N. Cogswell, the “structural” entities were identified over a size range from nanometers to fractions of millimeters, i.e., over 5 to 6 orders of magnitude.

² The IUPAC Working Party study on these materials – called IUPAC LDPE A, B and C – initiated several further studies outside IUPAC essentially on the same type but different batches of the LDPE product– including IUPAC LDPE Melt 1 and IUPAC LDPE X. This is why this type of LDPE probably represents the most widely characterised polymer melt in the literature today.

There was a large interest in relating impact toughness to the performance of fabricated parts. S. Turner led a project [14] where impact properties were measured for a propylene homopolymer in a number of different ways and on various types of specimens. It transpires that this study was “far from straightforward” but a potential value of a falling dart test was established.

As P.L. Clegg’s report [18] shows, the preceding were not the only projects reported-on during the period up to the end of 1980. However, they do capture the flavour of the projects, together with the concerns and preoccupations of the Working Party. In addition, there was a proper interest in the value that industry perceived in the outcomes of the Working Party. Clegg [18] describes the various measures of this value and all of this happened before the world of “quality” was invented!

The collaborative project dealing with styrene-butadiene-styrene (SBS) block copolymers co-ordinated by A. Ghijssels and J. Raadsen [12,13] led the Working Party for the first time into the new area of multiphase melts showing peculiar properties due to the underlying morphology.

In the period between 1963 and 1980 the Working Party held 37 meetings, all of which were in Western Europe. However, there was a strong presence from the USA in the membership of the group and not surprisingly the Working Party held its first meeting in the USA in 1981. In addition, two regional sub-groups were established in the early 1980s. The first was established in Japan (the East Asian Sub-Group) and benefited from new members from Japan, China and Korea. The second was an Eastern European Sub-Group with new members from Czechoslovakia, Hungary, Poland and the USSR (as these countries were then defined). The motivation for the formation of these sub-groups was to expand membership on a global basis and to ease travel (restricted by cost or political conditions). Each sub-group established its own projects and reported to the main Working Party.

The first publication from a project of the East Asian Sub-Group was on viscoelastic properties of rubber-modified polymers [20]. The second covered the relationship between molecular characteristics and physical properties of linear, low-density polyethylenes [21]. This continued a historic theme within the Working Party, but in this study a comparison was made between conventional high pressure polyethylene materials and the emerging linear low density (low pressure) polyethylene materials. Yet again there was an interest in film processes. As they edged towards establishing a new working relationship, the Eastern European Sub-Group conducted a project on the structure-processing of tertiary composites based on polypropylene.

Noteworthy was a sub-group comprising prominent theoretical rheologists that was formed within the Working Party to investigate the applicability of existing rheological constitutive equations to the observed flow behaviour of polymer melts. It was the first project without any measurements. The final publication by A.S. Lodge et al. [17] focused on Gaussian molecular network theories.

The Middle Years (ca.1981 - ca.1992)

(Table 2 contains the list of meetings held in this period)

Over several years, the experts in mechanical properties and melt rheology had separate meetings to focus on their respective areas. This format of meeting was given up, again in favour of joint meetings for all members. From the early 1980s onwards the Working Party expanded its activities on three fronts:

First, it further developed its activities trying to understand impact behaviour of injection mouldings in projects led by C.B. Bucknall [24,25]. Part of this study attempted to understand impact toughness of polypropylene from falling dart tests in terms of weld lines and ejector pin marks. In addition, it tried to account for weld lines in polyethylene and nylon 6.6 in terms of surface defects and fracture mechanics analysis.

The second development involved feasibility studies for understanding polymer blends in terms of processing-structure-property relationships. In particular, in projects led by H.M. Laun and P. Hope, the Working Party started work on suitably selected model systems for miscible and immiscible blends based on technical polymers. These projects will be discussed later. In East Asia there were also projects relating to structure-property relationships for polybutadiene-rubber blends [26].

The third development involved establishing some projects on contemporary polymeric materials and systems. Polymeric fibre-reinforced composites were fast emerging and the Working Party was well placed to contribute to this area. Therefore, in the early 1980s, projects were started by D.R. Moore and J.C. Seferis on continuous carbon-fibre reinforced semi-crystalline polymers. This was followed by projects led by A. Cervenka and P.S. Allan on discontinuous fibre-reinforced polymeric systems; more of these later.

The East Asian Sub-Group was operating on similar lines. It conducted a project on the characterisation of commercially available poly(acrylonitrile)-based carbon fibres [23]. This study included detailed structural characterisation from electron microscopy (scanning and transmission), electron diffraction and electron energy-loss spectroscopy (XPS). In addition, the use of Raman spectroscopy, Fourier Transform Infra Red (FT-IR) spectroscopy, solid state high resolution NMR and secondary-ion mass spectroscopy (SIMS) provided molecular characterisation. These characteristics were linked to a selection of mechanical properties of the fibres. The study established the ability of the Working Party to conduct powerful state-of-the art science. These projects were supplemented within the East Asian sub-group with structure-property investigations into poly(vinyl alcohol) [32], and structure-dielectric property relations of vinylidene fluoride copolymers [31] and ultra high-molecular-weight polyethylene near its melt temperature [37], as well as investigations of ageing effects in commercial polymers [39].

The traditional interest that the Working Party has had in linking rheological properties to processing was not lost during this period. J.L. White attended to this with two projects. The first explored a link between rheological properties and unstable melt-spinning for linear and branched poly(ethylene terephthalates) [22]. A branched

sample exhibited much greater spin-line stability than the linear polyester. The second project examined the stability of extrusion, melt spinning and tubular film extrusion for some high-density, low-density, and linear-low-density polyethylene samples [27].

The Period to the New Millennium (ca.1991-1999)

(Table 2 contains the list of meetings held in this period)

These were years of considerable achievement but they were also what can be described as the political period. IUPAC was attempting considerable restructuring and this naturally had a profound influence on the administrative and organisational aspects of the Working Party, but almost no influence on its being and activities. The ramifications of the restructuring within IUPAC need not concern us now, but one of its consequences was the removal of sub-groups. However, it was important to the Working Party to retain the scientific activities and contacts, now well-established within its East European and East Asian Sub-Groups.

The existence of *détente* and political freedom within continental Europe provided ease of access and communication between scientists in the East and West. Therefore, the Working Party held meetings in Czechoslovakia (just before it became the Czech and Slovakia Republics) and in Poland in 1992 and 1993, respectively. This arrangement enabled scientists from the former Eastern Block countries to attend the meetings. The Working Party closed the East-Europe Sub-Group after these meetings and integrated the scientists involved into the main group.

The integration of the East Asian Sub-Group was more difficult because there were more substantial cost barriers to everyone meeting at a single location. An arrangement was established whereby the members of the sub-group became members of the Working Party but could hold a research meeting in their area once a year. This was consolidated with a full meeting of the Working Party being held in Korea in 1996. Ten of the 28 participants were members from Europe, USA and Canada.

Figure 1 shows the Working Party under the chairmanship of H.M. Laun at its 1995 meeting (meeting 53) in Amsterdam. **Figure 2** shows the participants of the meeting (meeting 54) in 1996, which was hosted by K. U. Kim at the Korea Institute of Science and Technology (KIST).

This period was an extremely active one for the Working Party. The new directions of scientific work defined in the mid -1980s became well established in the 1990s and we now examine some of these.

Polymeric fibre-reinforced composites became of significant interest for the Working Party. This was true, in particular, for composites that had potential for engineering parts in primary aerospace structures, namely continuous carbon-fibre reinforced thermoplastic composites. A project led by D.R. Moore and J.C. Seferis studied two materials systems of continuous carbon-fibre reinforced thermoplastics; one based on poly(ether ether ketone) and the other based on poly(ethylene terephthalate). The work was divided into four sections; toughness [36], elastic constants [38], structure

[40] and fatigue-crack growth [52]. A key feature in the overall study was to find a way of accommodating the massive anisotropy in these fibre-reinforced composites whilst retaining an ability to measure some conventional but important properties.



Figure 1: Working Party IV.2.1 meeting Amsterdam (1995) hosted by A. Cervenka from Shell. *Kneeling (from left): D. Dijkstra, A. Cervenka, sitting: G. Williams, R. S. Bailey (Secretary), H. M. Laun (Chairman), D. R. Moore (Commission IV.2 Chairman), J. Meissner, C.B. Bucknall, 1st row standing: C. Galiotis, B. Gunesin, L. Glas, J.L.S. White, T. Masuda, C. Dehennau, J. Lyngaae-Jørgenson, G. Michler, H. Steuten, 2nd and 3rd row standing: S.C. Kim, J. Covas, P. Hope, G. Bonner, F. Maurer, A. Coran, M. Kozlowski, T. Vu-Khan, G. Ajroldi, G. Zachmann, A. Duckett, W. Gleissle, M. Lecomte, B. Pukanszky, J. Curry*

A second fibre-reinforced composites project was led by P.S. Allan and A. Cervenka and became the largest single project undertaken by the Working Party. It had 21 participating laboratories and published seven papers [46-51,68]. It was concerned with the processing and properties of injection-moulded discontinuous fibre-reinforced thermoplastic composites. In this work both the fibre types (carbon, glass and aramid), fibre length and fibre orientation were controlled, as was the choice of resin system (polyamide and polypropylene). It was recognised that the injection moulding of these composites produces complex structures in the plane of and through the thickness of the mouldings. Therefore, the aims of the study were to provide characterisation of the processing-property-structure relationships that characterise this complexity. The study was structured to encompass preparation of the samples and control of the variables [46], an overview of the properties [47], cross-section heterogeneity [48], structural studies [49], prediction of stiffness [50],

measurement of rheological properties [51] and, eventually, rheological studies on reprocessed material [68].

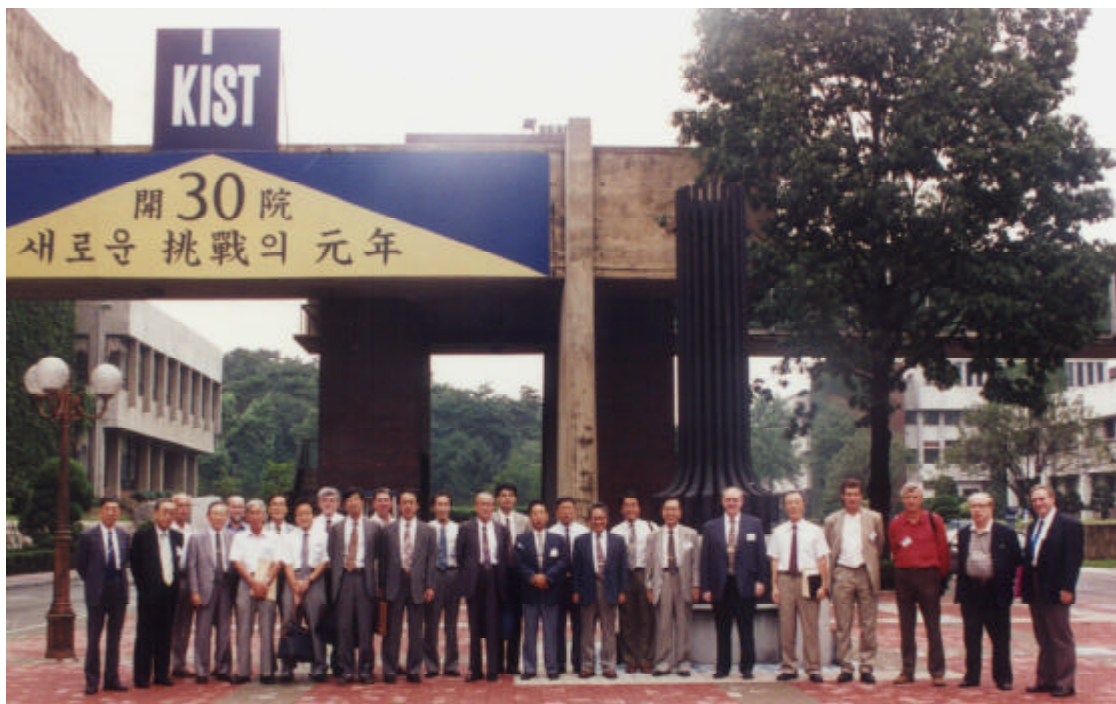


Figure 2: Working Party IV.2.1 Meeting in Seoul (1996) hosted by K. U. Kim at KIST. Participants (from right): J. Lyngaae-Jørgenson, J. L. White, D. R. Moore (chairman Commission IV.2), R. S. Bailey (secretary), C. R. Choe, H. M. Laun (chairman), K. U. Kim (host), T. Vu-Khanh, T. Masuda (chairman East Asia research meeting), J. S. He, H. Ishihara, A. Izuka, T. Hayashi, M. D. Takahashi, M. Mochizuki, J. Curry, K. Nakayama, F. Ramsteiner, T. Kobatake, J. C. Jung, S. Tsuchiya, W. Gleissle, Y. Yoshioka, G. H. Michler, M. Hirami, B. Z. Jiang.

In contrast to this considerable experimental programme, a third composites project led by D.R. Moore and A. Cervenka focused on future requirements for the characterisation of continuous-fibre-reinforced composites. In this study, contributing scientists reviewed some of the history in processing and properties of these composite materials and tried to identify the factors that would be important in the future [72]. This was the first project where the Working Party had a philosophical output rather than an experimental one.

A study on structure-property relations of biodegradable poly(hexano-6-lactone) fibers was carried out by the East Asia Sub-Group. The results on the degradation behaviour in soil and water are documented by three publications [54,57,69].

This period also saw a considerable focus by the Working Party on blended polymeric systems and copolymers. A desire from industry to develop new products by adapting already available materials, rather than through the synthesis of new polymers, was accommodated ably within the Working Party whose motive was the understanding of the potential and performance of these systems. Several projects were progressed. For example, the East Asia Sub-Group studied the molecular characteristics and

crystalline structure of ethylene-dimethylaminoethyl-methacrylate copolymers [41]. This was followed by further work on the properties of the same copolymers as modifiers in poly(vinyl chloride) formulations [42] and then modifiers in polypropylene formulations [43].

Meanwhile a major strategic thrust was being developed in the main Working Party on immiscible and miscible blends. The first blends project co-ordinated by A.P. Plochocki [76], was a joint study of the effect of mixing and processing conditions on the phase morphology and rheology of polystyrene/low-density polyethylene (PS/LDPE) blends. Several earlier publications represent either individual contributions [30, 34] or acknowledge results from that study [e.g., 29, 33, 35].

A second study was led by P. S. Hope and J. E. Curry and focused on the reactive blending of immiscible blend components. In the first part of the project, the reactive blending of ethylene-vinyl alcohol and styrene-maleic anhydride copolymer, as well as the resulting structure and rheology were investigated [44]. The second part studied the property improvement via interfacial chemical reaction of nylon 12 and maleic-anhydride-grafted ethylene-propylene-copolymer rubber [60].

The project on miscible blends was co-ordinated by H. M. Laun, J. Lyngaae-Jorgensen and V. Alstädt and based on blends of poly(α -methyl styrene-co-acrylonitrile) with poly(methyl methacrylate) P α MSAN/PMMA [55]. This ambitious project focused on the preparation of blends of various morphologies but with the same composition of the constituents and the study of the effects of morphology on rheological and mechanical properties. The constituents were very similar in their viscoelastic behaviour. The shift of the regime of miscibility by simple shear flow was investigated [53]. The observed morphology changes in oscillatory shear were compared with available theories for droplet/matrix and co-continuous structures [56, 59, 61], as well as with phase-separation simulations [62]. Various rheological techniques to determine the interfacial tension have been applied [73]. The composition and temperature dependence of the interaction parameter χ was quantified by means of neutron diffraction and cloud-point studies for blends of P α MSAN with PMMA [66] and with poly(methylacrylate-co-methylmethacrylate) [74]. Finally, the effects of morphology on the mechanical properties of the blends were widely investigated [75].

Another large project on blends was established by C. B. Bucknall and M. Kozlowski. In this work, the addition of “core-shell” rubber particles to thermoplastic matrix materials was studied in terms of enhancement of toughness. The aim was to understand the mechanisms involved in the toughening process. Therefore, two rubber-particle systems were selected, polybutadiene and poly(butyl acrylate-co-styrene), having quite different glass-rubber transition temperatures. These were blended with four different thermoplastic matrix materials (polycarbonate, poly(methyl methacrylate), poly(styrene-co-acrylonitrile) and poly(vinyl chloride)) at the same volume concentration of the rubber. Mechanical and rheological properties of these systems were investigated [63, 64]. Structural and deformational mechanisms were discussed for tensile impact behaviour [65], dart-drop and notched bending tests [70], and fatigue behaviour [71]. A transmission-electron-microscopic investigation of in situ deformation was published [45].

During this period, other studies were also conducted. For example, D.R. Moore and C. Dehennau led a study of the factors that influence the reprocessing of plasticised poly(vinyl chloride) [58]. This work was aimed at using processing-structure-property relationships to understand why heat and shear histories cause difficulties in the reprocessing.

J.L. White led a project on the characterisation of the flow behaviour, structure and properties of liquid-crystalline polymers, including cellulose derivatives. The aim was to address the special rheological properties of that class of polymers in comparison to a non-liquid-crystalline aromatic high-temperature thermoplastic [67].

The effects of long chain branching in commercial polycarbonate with a focus on its processability in blow moulding, extrusion and injection moulding, as well as on its solid-state properties, were the subjects of a collaborative project coordinated by M. Takahashi, K. Sato and T. Masuda [77, 78]. This study was initiated and carried out mainly by the East Asia members of the Working Party but there were also contributions from European members.

Structure-property relations for hydrogenated poly(acrylonitrile-butadiene) rubber (HNBR) were investigated by the East Asia members in a joint study led by T. Kobatake and T. Masuda [79, 80]. The work covered both dilute solutions and concentrated systems.

The new millenium

Following the Strategy Development and Implementation Committee (SDIC) recommendations of 1998, the Macromolecular Division moved to a project-driven system. As a direct consequence, from 2000 onwards, the Working Party no longer held an official status within IUPAC. It became an ad-hoc working group, although it continued its project-oriented mode of operation. There was also a clear decision of the all Working Party members to retain the existing benefits of the Working Party structure for their collaborative work. To be consistent with the new task-group operation of the Division, the Chairman of the Working Party became one of the Characterisation Co-ordinators within the Division, while both the Secretary of the Working Party and the Chairman of the East Asian Research Meeting were acting also as Task Group Chairmen of projects within the Division.

R. B. Bailey (Secretary) became Task Group Chairman of a five-year project on “Quantifying scratch resistance of commercial polymers”. The goal is to consider the range of scratching, abrasion and erosion techniques used in the plastics industry and to apply a more fundamental understanding of the issues that contribute towards scratch resistance. In stage 1 of the project, key links between bulk and coating mechanical properties and scratch and abrasion resistance are to be identified using generic techniques to manufacture materials with a so called ‘scratch-resistant’ surface on acrylic and polycarbonate polymers. Stage 2 is focusing on emerging and novel scratch-resistant coatings.

S. C. Kim became Task Group Chairman of a three-year project on “Structure and properties of cyclic olefin copolymers (COC)”. Here, the focus is on relating the

chemical structure of commercially available COCs to rheological and processing properties as well as to optical and mechanical properties in the solid state.

In 2002, a former feasibility study of the East Asia members was transferred into a three-year project on “Structure and properties of polyester elastomers composed of poly(butylene terephthalate) and poly(ϵ -caprolactone)” with T. Tagigawa as Task Group Chairman. Sub-topics of the joint study are (i) molecular structure, (ii) rheological properties, (iii) rubber elasticity, (iv) aggregate structure and deformation mechanism, and (v) blends with other polymers.



Figure 3: Working Party IV.2.1 research meeting in Ludwigshafen (2003) hosted by H. M. Laun at BASF. *Participants (from left): Front row: S. Monsheimer (Degussa), U. Handge (ETH Zürich), H. M. Laun (BASF), A. Machado (Guimares), Ch. Chai (BP chemicals), W. Gleissle (Karlsruhe), G. Ourieva (Exxon Mobile), J. Lyngaae-Jørgenson (Lyngby). Middle rows: P. Pelz (Freudenberg), M. Rüllmann (BASF), D. Stocks (ICI), R. S. Bailey (ICI), D. Dijkstra (Bayer), J. Meissner (ETH Zürich), R. Koopmans (DOW), V. Rouyer (BP Solvay), T. Inoue (Kyoto), G. Biebaut (Shell), H. Steininger (BASF), V. Altstädt (Bayreuth). Back rows: R. Brummer (Beiersdorf), F. Ramsteiner (BASF), W. Zoetelief (DSM), B. Hochstein (Karlsruhe), I. Fortelny (Prague), C. Gabriel (Basell), U. Göschel (Stuttgart), E. Piorkowska-Galeska (Lodz), C.B. Bucknall (Cranfield), T. Tagigawa (Kyoto), K. Nitta (JAIST), A. Galeski (Lodz), F. Langouche (Solvay), E. Wassner (Elastogran), B. Ouriev (Bühler AG).*

The Working Party amended its rules to make all communications electronically by means of e-mail. A Working Party homepage (<http://www.launweb.de/iupac>) was set up by H. M. Laun to keep the documentation on projects, reports, people and actions continuously updated. It contains a public sector open for everybody interested in the

activities and meetings of the Working Party as well as a private sector for members only.

Figure 3 shows the participants of research meeting No. 60B at BASF in Ludwigshafen on January 14 & 15, 2003, hosted by H M. Laun. It was, in fact, the 68th meeting of the Working Party and it was successful in broadening the industrial membership. Valuable discussions and networking, which also continued during the social programme, helped to improve the structure of new studies as well as obtaining numerous commitments for written, experimental, and numerical modelling contributions. A celebration was held in recognition of Joachim Meissner's 35 years of active membership of the Working Party.

A major challenge for the Working Party, in particular for the coordinators of running projects as well as for the Working Party Chairman, was the need, imposed by the change of IUPAC policy, to finalise all old IUPAC projects by the end of 2001. Impressively, through an enormous effort of the group, this goal was in fact reached. A total of 12 publications appeared in 1999 to 2002 and another 13 were in the publication pipeline at the end of 2002.

Following the new IUPAC guidelines, projects have limited life-times of about 3 years. Based on the experience from the Working Party, this time-frame is usually not adequate for voluntary and unfunded joint experimental work. A period of 5 to 8 years is more realistic. Therefore, proposals for new projects within the Working Party that realise sufficient participation are converted into feasibility studies in which the outline and goal of the work, the supplier of the material, the contributors from inside and outside the Working Party and the coordinators are defined. This step often includes some screening measurements. Once a convincing tactical plan, including milestones has been developed, a project application is submitted to IUPAC via the Macromolecular Division Co-ordinator. Such studies that will occupy the Working Party over the next few years include:

- (i) Structure and properties of linear and crosslinked, structural PVC foams.
- (ii) Flow properties of ceramic and metal injection-moulding feed stocks.
- (iii) Recommendations for data presentation applicable to mechanical and rheological measurements of polymers.
- (iv) Critical check of capillary-flow predictions using viscoelastic finite-element simulation and IUPAC LDPE literature data.
- (v) The role of stress-induced cavitation in mechanical performance of semi-crystalline polymers.
- (vi) Rheological characterisation of polyamides.
- (vii) Future developments of new materials based on commodity polymers by physical structure and morphology alteration.
- (viii) Investigation of morphology parameters governing the properties of melt-processable filled polymers.

Clearly, the Working Party remains on a highly active course. The remarkable output of Working Party IV.2.1 caused Bob Stepto, President of the Macromolecular

Division, to propose making the Working Party a Subcommittee of the Division. The corresponding application was accepted at the Ottawa General Assembly of IUPAC in 2003. This makes the Working Party again an official part of the IUPAC Macromolecular Division, a most welcome change of status for the 40th anniversary of the group. As one of the consequences of the formation of the Subcommittee, the homepage of the group will be transferred onto the IUPAC server.

3 The Motivation and Future Role of the Working Party

The remit of the Working Party was set in its early days. It was broad ranging and flexible, and it has not altered significantly over the years. The group existed within an organisational structure that was established, modified and audited by IUPAC. The organisational chain of “command” provided links into the Working Party but did not define its activities although it did monitor them. Therefore, the group’s project base was self-defined and the consequences of this are extremely important.

First, the Working Party initiated projects that it knew were of relevance and importance to industry, academia and the world at large. The balanced membership base from industry and academy therefore worked to ensure that projects were structured so as to provide value in application, need and scientific novelty. Also, in a general sense, the work had to be convincing to the paymasters, namely, industrial managers or academic supervisors. It was, therefore, obligatory to ensure that the appropriate skills were present and active in the Working Party. Consequently, it was necessary that the Working Party organised itself to have the skills and level of activity necessary to achieve the right efficiency and output.

Second, the members of the Working Party enjoy working with like-minded scientists on a global basis. It offers them contacts and networks that would be difficult to establish by any other means. In addition, the value that is generated by a scientific project in which an individual (or his or her organisation) is funding only a fraction of the cost can readily be seen to be considerable.

Third, the definition of a project by its Task Group Members ensures that the project is of contemporary value and importance. Common themes that are important to several industrial scientists can be turned into a useful but non-competitive project. Further, seeking academic involvement often provides useful input from a leading expert in the field. There are moves within the broader IUPAC organisation to generate and define projects on a top-down basis (rather than the bottom-up one just described). Even if such a move is successful, it will be vital to retain some projects that come from the bottom-up approach.

The activity of its members is a key feature of the success of the Working Party. The success can be measured, for example, by the impressive number of publications and the high citation indices of the major papers it has published. To keep its enormously successful track record and to maintain its high level of activity, the Working Party has set up rules that ensure continual rejuvenation of the group. The “Rules and Codes of Practice” are given in the Appendix.

As stated, the driving force within the Working Party have been its members and their motivation to obtain value (to them and their businesses) from participation in the group. If value is obtained then their businesses fund their participation. This procedure has operated for 40 years during which time many different and changing economic climates have existed. Unless future economic climates are completely different from those of the past (which is unlikely) then there is no underlying reason to have lack of confidence in the future continuing success of the Working Party.

The remit of the Working Party will continue to operate via an international network of scientists whose interests lie within the broad field of the structure and properties of commercial polymer materials. It will continue to pursue projects that have contemporary value and that lead to publications. The types of materials and the approaches used will change in the future, as they have in the past. However, there will always remain issues relating to polymeric systems or particular properties that will need to be characterised and understood.

There is likely to be demand for shorter projects in the future, as impatience for return on investment is always present. A recent trial in documenting the views and opinions of the Working Party [72] demonstrated a possible approach, where a philosophical document on the future requirements for the characterisation of composites was written. This type of approach might also provide an opportunity for the group to document a philosophy in other areas of characterisation based solely on its knowledge base as opposed to its capability for conducting new measurements. The decline in major corporate organisations in the chemical industry suggests that this need could be larger than we might predict.

Some of the completed projects have provided comprehensive data on commercial polymers that are still available and may be used for further research outside of the Working Party. Recent examples are poly(α -methylstyrene-co-acrylonitrile) (P α MSAN) and poly(ethyl methacrylate) (PMMA) and their blends [55]. Besides a rheological [55, 56, 59] and mechanical [75] characterisation of the constituents and their blends, there is valuable information available on the interfacial tension [73] as well as the interaction parameter χ as a function of temperature [66] and composition [74]. Further studies on this system are explicitly encouraged by the Working Party.

There are also educational or training values that the Working Party could satisfy. A new recruit could serve a few years on the Working Party in order to become acquainted with the network of activities and people or merely to learn a different approach to conducting research or a project.

The future will unquestionably lie with the people involved. It will depend on whether they are committed to the broader aims of the Working Party and if they are ambitious to reap the rewards. It will depend on whether they involve others in the activities of the group because they see and appreciate its benefits. Finally, it will depend on whether they communicate regarding the values and virtues of the Working Party and in so doing underpin the desire of their organisations to see them continue involvement in its activities. It will be interesting to watch the developments in the years ahead.

Acknowledgements

The authors are very grateful to Joachim Meissner, Wolfgang Retting and Toshira Masuda for carefully reading the manuscript and providing valuable additional information.

References

- [1] T. T. Jones, *J. Polym. Sci., Part C*, 16, 3845 –3864 (1968), ‘The relationship of performance characteristics to basic parameters of polymers. I. A collaborative study of polystyrene using torsion pendulum and impact methods’.
- [2] A. Gonze, *Pure Appl. Chem.*, 18, 551 – 568 (1969), ‘A collaborative study of the dynamic mechanical and impact properties of polyvinylchloride. I’.
- [3] J. S. L. Wales, *Pure Appl. Chem.*, 20, 331 – 363 (1969), ‘A collaborative investigation into the rheology of some polystyrene and polyethylene melts’.
- [4] H. Oberst and W. Retting, *J. Macromol. Sci. –Phys.*, B5, 559-590 (1971), ‘Influence of molecular relaxation processes on mechanical properties of polyvinyl chloride in tensile experiments’.
- [5] A. Gonze and J. C. Chauffoureaux, *Pure Appl. Chem.*, 35, 315-351 (1973), ‘A collaborative study of the dynamic mechanical and impact properties of PVC . II’.
- [6] J. L. Wales, *J. Poly. Sci. Symposium* No. 50, 469-485 (1975), ‘A collaborative study of capillary flow of a highly lubricated unplasticized poly (vinyl chloride)’.
- [7] J. Meissner, *Pure Appl. Chem.*, 42, 553-612 (1975), ‘Basic parameters, melt rheology, processing and end-use properties of three similar low density polyethylene samples’.
- [8] J. C. Chauffoureaux, *Pure Appl. Chem.*, 47, 333-339 (1976), ‘A collaborative study on tensile properties of rigid PVC. Long-time transition’.
- [9] W. Retting, *Pure Appl. Chem.*, 50, 1725-1762 (1978), ‘The effect of molecular orientation on the mechanical properties of rubber-modified polystyrene’.
- [10] J. C. Chauffoureaux, *Pure Appl. Chem.*, 51, 1123-1147 (1979), ‘Mechanical properties of rigid polyvinyl chloride. Effect of fillers’.
- [11] F. N. Cogswell, *Pure Appl. Chem.*, 52, 2031-2050 (1980), ‘Sub-primary particles in PVC - Identification and elucidation of their role during flow’.
- [12] A. Ghijssels, J. Raadsen, *Pure Appl. Chem.*, 52, 1359-1386 (1980), ‘A collaborative study on the melt rheology of a styrene-butadiene-styrene block copolymer’.
- [13] A. Ghijssels and J. Raadsen, *J. Polym. Sci., Phys. Ed.*, 18, 397-399 (1980), ‘Development of a residual shear stress an an SBS block copolymer during stress relaxation following steady-state flow’.
- [14] S. Turner, *Pure Appl. Chem.*, 52, 2739-2769 (1980), ‘A study of impact strength testing and its relevance to real mouldings’.
- [15] A. J. de Vries, *Pure Appl. Chem.*, 53, 1011-1037 (1981), ‘Structure and properties of uni- and biaxially oriented polypropylene films: Part 1- Structural characterization’.
- [16] A. J. de Vries, *Pure Appl. Chem.*, 54, 547-670 (1982), ‘Structure and properties of uni- and biaxially oriented polypropylene films: Part 2 - Mechanical and other end-use properties’.

- [17] A. S. Lodge, R. C. Armstrong, M. H. Wagner, H. H. Winter, *Pure Appl. Chem.*, 54, 1349-1359 (1982), 'Constitutive equations from gaussian molecular network theories in polymer rheology'.
- [18] P. L. Clegg, *Pure Appl. Chem.* 55, 755-764 (1983), 'Collaborative research on polymeric materials through IUPAC'.
- [19] H. H. Winter, *Pure Appl. Chem.*, 55, 943-976 (1983), 'A collaborative study on the relation between film blowing performance and rheological properties of two low-density and two high-density polyethylene samples'.
- [20] T. Masuda, A. Nakajima, M. Kitamura, Y. Aoki, N. Yamauchi, A. Yoshiako, *Pure Appl. Chem.*, 56, 1457 – 1475 (1984), 'Viscoelastic properties of rubber modified polymeric materials at elevated temperatures'.
- [21] A. Furumiya, Y. Akana, Y. Ushida, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 57, 823-832 (1985), 'Relationship between molecular characteristics and physical properties of linear low density polyethylenes'.
- [22] J. L. White, H. Yamane, *Pure Appl. Chem.*, 57, 1441-1452 (1985), 'A collaborative study of the rheological properties and unstable melt spinning characteristics of linear and branched polyethylene terephthalates'.
- [23] K. Morita, Y. Murata, A. Ishitani, K. Murayama, T. Ono, A. Nakajima, *Pure Appl. Chem.*, 58, 455-468 (1986), 'Characterization of commercially available pan (polyacrylonitrile)-based carbon fibers'.
- [24] C. B. Bucknall, *Pure Appl. Chem.*, 58, 985-998 (1986), 'Impact of polypropylene mouldings'.
- [25] C. B. Bucknall, *Pure Appl. Chem.*, 58, 999-1014 (1986), 'Application of fracture mechanics to the prediction of the ductile-brittle transition'.
- [26] A. Yoshioka, K. Komuro, A. Ueda, H. Watanabe, S. Akita, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 58, 1697-1706 (1986), 'Structure and physical properties of high-vinyl polybutadiene rubbers and their blends'.
- [27] J. L. White, H. Yamane, *Pure Appl. Chem.*, 59, 1193-216 (1987), 'A collaborative study of the stability of extrusion, melt spinning and tubular film extrusion of some high-, low- and linear-low density polyethylene samples'.
- [28] J. M. Cann, *Pure Appl. Chem.*, 59, 217-220 (1987), 'The onset of runaway creep in HIPS (high impact polystyrene): A study in variability'.
- [29] A. P. Plochocki, S. S. Dagli, H. H. Mack, *Kunststoffe*, 78, 254-260 (1988), 'Morphologie von Polymergemischen und Polymerblends'.
- [30] L. A. Utracki and P. Sammut, *Polym. Eng. Sci.*, 28, 1405-1415 (1988), 'Rheological evaluation of polytyrene/polyethylene blends.'
- [31] Y. Kubouchi, Y. Kometani, T. Yagi, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 61, 83-90 (1989), 'Structure and dielectric properties of vinylidene fluoride copolymers'.
- [32] S. Amiya, S. Tsuchiya, R. Qian, A. Nakajima, *Pure Appl. Chem.*, 62, 2139-2146 (1990), 'The study of microstructures of poly(vinyl alcohol) by NMR'.

- [33] A. P. Plochocki, S. S. Dagli, R. D. Andrews, *Polymer Eng. Sci.*, 30, 741-752 (1990), 'The interface in binary mixtures of polymers containing a corresponding block copolymer: Effects of industrial mixing processes and of coalescence'.
- [34] L. A. Utracki and P. Sammut, *Polym. Eng. Sci.*, 30, 1019-1026 (1990), 'On the uniaxial elongational flow of polystyrene/polyethylene blends.'
- [35] A. P. Plochocki, P. S. Hope, J. E. Curry, *ANTEC '91*, 707-716 (1991), 'Fabrication of a standard industrial polyblend/alloy: Repeatability of the compounding process'.
- [36] D. R. Moore, J. C. Seferis, *Pure Appl. Chem.*, 63, 1609-1625 (1991), 'Toughness characterization of carbon fibre/polyether ether ketone (CF/PEEK) laminates'.
- [37] K. Nakayama, A. Furumiya, T. Okamoto, K. Yagi, A. Kaito, C. R. Choe, L. Wu, G. Zhang, L. Xiu, D. Liu, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 63, 1793-1804 (1991), 'Structure and mechanical properties of ultra-high-molecular weight polyethylene deformed near melting temperature'.
- [38] A. Cervenka, D. R. Moore, J. C. Seferis, *Pure Appl. Chem.*, 64, 1801-1808 (1992), 'Pseudo-elastic constants for aromatic polymer composite (APC-2)'.
- [39] H. Kondo, T. Tanaka, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 64, 1945-1958 (1992), 'Ageing effects in 16 years on mechanical properties of commercial polymers'.
- [40] J. C. Seferis, D. R. Moore, H. G. Zachmann, *Pure Appl. Chem.*, 65, 1581-1593 (1993), 'A collaborative study of the structure and morphology in continuous fiber reinforced PET and PEEK'.
- [41] T. Ohmae, S. Hosoda, H. Tanaka, H. Kihara, B. Jiang, Q. Ying, R. Qian, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 65, 1825-1847 (1993), 'Molecular characteristics and crystalline structure of ethylene-dimethylaminoethyl-methacrylate copolymers'.
- [42] S. C. Kim, B. S. Jin, T. Ohmae, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 66, 1405-1414 (1994), 'Properties of ethylene-dimethylaminoethylmethacrylate copolymers as poly(vinyl chloride) resin modifier'.
- [43] R. Qian, Y. Xu, Y. Chen, D. Shen, X. Jin, L. Chen, T. Ohmae, S. Hosoda, H. Tanaka, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 67, 2047-2056 (1995), 'Properties of EDAM copolymers as polypropylene resin modifier'.
- [44] P. S. Hope, J. G. Bonner, J. E. Curry, *Pure Appl. Chem.*, 68, 1665-1682 (1996), 'A collaborative study of the structure and rheological properties of EVOH/SMA-blends produced by reactive extrusion'.
- [45] J. U. Starke, R. Godehardt, G. H. Michler, C. B. Bucknall, *J. Mater. Sci.*, 32, 1855-1860 (1996), 'Transmission electron microscopic investigation of in situ deformation of toughened SAN-modified by core-shell-particles at various temperatures'.
- [46] A. Cervenka, P. S. Allan, *Pure Appl. Chem.*, 69, 1693-1705 (1997), 'Characterisation of finite length composites: Part I. Introductory paper'.
- [47] L. Glas, P. S. Allan, T. Vu-Khanh, A. Cervenka, *Pure Appl. Chem.*, 69, 1707-1723 (1997), 'Characterisation of finite length composites: Part II. Mechanical performance of injection molded composites'.

- [48] A. Cervenka, P. S. Allan, *Pure Appl. Chem.*, 69, 1725-1740 (1997), 'Characterisation of finite length composites: Part III. Studies on thin sections extracted from moldings (wafers)'.
- [49] G. J. von Bradsky, R. S. Bailey, A. Cervenka, H. G. Zachmann, P. S. Allan *Pure Appl. Chem.*, 69, 2523-1539 (1997), 'Characterisation of finite length composites: Part IV. Structural studies on injection moulded composites'.
- [50] P. S. Allan, A. Cervenka, D. R. Moore, *Pure Appl. Chem.*, 69, 1741-1751 (1997), 'Characterisation of finite length composites: Part V. Modelling of stiffness'.
- [51] R. S. Bailey, D. J. Groves, *Pure Appl. Chem.*, 69, 2541-2565 (1997), 'Characterisation of finite length composites: Part VI. Rheological studies of materials based on the polypropylene matrix'.
- [52] D. R. Moore, J. C. Seferis, *Pure Appl. Chem.*, 69, 1153-1161 (1997), 'Intrinsic characterisation of continuous carbon fibre thermoplastic composites - 3. Fatigue crack growth'.
- [53] V. Schytt and J. Lyngaae-Jørgensen, *Polym. Networks Blends*, 7, 77-86 (1997), 'Rheological and mechanical properties of P α MSAN/PMMA blends in miscible and phase separated regimes of various morphologies. Part 2. Limits of miscibility in the quiescent state and during flow'.
- [54] M. Mochizuki, K. Nakajima, R. Qian, B.-Z. Jiang, M. Hiram, T. Hayashi, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 69, 2567-2575 (1997), 'Studies on biodegradable poly(hexano-6-lactone) fibers. Part 1. Structure and properties of drawn PLC fibres'.
- [55] H. M. Laun, *Pure Appl. Chem.*, 70, 1547-1566 (1998), 'Rheological and mechanical properties of poly(α -methylstyrene-co-acrylonitrile)/poly(ethyl methacrylate) blends in miscible and phase separated regimes of various morphologies. Part 1. Characterization of constituents, blend preparation, and overview on blend morphology'.
- [56] I. Vinckier and H. M. Laun, *Rheol. Acta*, 38, 274-286 (1999), 'Manifestation of phase separation processes in oscillatory shear: droplet-matrix systems versus co-continuous morphologies'.
- [57] M. Mochizuki, K. Nakajima, R. Qian, B.-Z. Jiang, M. Hiram, T. Masuda, A. Nakajima, *Pure Appl. Chem.*, 71, 2177-2188 (1999), 'Studies on biodegradable poly(hexano-6-lactone) fibers. Part 2. Environmental degradation'.
- [58] C. Dehennau, D. R. Moore, *Pure Appl. Chem.*, 71 2317-2332 (1999), 'The influence of reprocessing on the structure-property characteristics of a plasticized poly(vinyl chloride) compound'.
- [59] I. Vinckier and H.M. Laun, *Macromol. Symp.*, 149, 151-156 (2000), 'Manifestation of spinodal decomposition in oscillatory shear measurements'.
- [60] J. E. Curry, P. S. Hope, J. G. Bonner, accepted for *Pure Appl. Chem.*(2001), 'Property improvement via interfacial chemical reaction – Reactive extrusion of polyamide 12 and maleic anhydride grafted ethylene propylene copolymer rubber'.
- [61] I. Vinckier and H.M. Laun, *J. Rheol.*, 45, 1373-1385 (2001), 'Assessment of the Doi-Ohta theory for co-continuous blends under oscillatory flow'.

- [62] Z.I. Zhang, H.D. Zhang, Y.L. Yang, I. Vinckier, H.M. Laun, *Macromolecules*, 34, 1416-1429 (2001), 'Rheology and morphology of phase-separating polymer blends'.
- [63] C. B. Bucknall, accepted for *Pure Appl. Chem.*, 73 (2001) 897-912, 'Blends containing core-shell impact modifiers. Part 1. Structure and tensile deformation mechanisms'.
- [64] M. Kozłowski and C. B. Bucknall, accepted for *Pure Appl. Chem.*, 73 (2001) 913-926, 'Blends containing core-shell impact modifiers. Part 2. Melt rheology of rubber toughened plastics'.
- [65] C. B. Bucknall and G. Ajroldi, accepted for *Plastics Rubber & Composites*, 30 (2001) 377-383, 'Blends containing core-shell impact modifiers. Part 2. Effects of temperature on tensile impact behaviour'.
- [66] D. W. Schubert, *Mat. Res. Innovat.*, 4, 353-359 (2001), 'Compatibility of poly(α -methylstyrene-co-acrylonitrile) with PMMA. A neutron and cloud point study'.
- [67] J. L. White, L. Dong, P. Han, submitted to *Pure Appl. Chem.* (2001), 'The rheological properties and associated structural characteristics of some aromatic polycondensates including liquid crystalline polyesters and cellulose derivatives'.
- [68] W. Gleissle, *Polymer Eng. Sci.* 18, 20-32 (2002), 'Characterisation of finite length composites: Part VII. Rheological studies of processed polypropylene-glass composites'.
- [69] T. Hayashi, K. Nakayama, M. Mochizuki, T. Masuda, *Pure Appl. Chem.*, 74, 869-880 (2002), 'Studies on biodegradable poly(hexano-6-lactone) fibers. Part 3. Enzymatic degradation in vitro'.
- [70] C. B. Bucknall, submitted to *Plastics Rubber & Composites* (2002), 'Blends containing core-shell impact modifiers. Part 4. Fracture in dart-drop and notched bending tests'.
- [71] C. B. Bucknall, submitted to *Plastics Rubber & Composites* (2002), 'Blends containing core-shell impact modifiers. Part 5. Fatigue behaviour'.
- [72] D. R. Moore, A. Cervenka, *Pure Appl. Chem.*, 74, 601-628 (2002), 'Future requirements in the characterisation of continuous fibre reinforced polymeric composites'.
- [73] I. Vinckier, T. Schweizer, H. M. Laun, *J. Polym. Sci. Part B*, 40, 679-690 (2002), 'Interfacial tension in a LCST blend: Effect of temperature, blend composition and deformation of the interphase'.
- [74] F. Havermeier and D. W. Schubert, *Mat. Res. Innovat.*, 6, 185-188 (2002). 'Consistent analysis of cloud points and spinodal - copatibility of P(α MS-co-AN) and P(MA-co-MMA)'.
- [75] V. Altstädt, L. de Lucca Freitas, D. W. Schubert, submitted to *Pure Appl. Chem.*, (2002), 'Rheological and mechanical properties of poly(α -methylstyrene-co-acrylonitrile)/poly(methylmethacrylate) blends in miscible and phase separated regimes of various morphologies. Part 4. Influence of the morphology on the mechanical properties'.

- [76] A. P. Plochocki, submitted to *Pure Appl. Chem.* (2002), 'Melt rheology and concomitant morphology of a model binary mixture of poly(ethylene) and poly(styrene) (polyblend)'.
- [77] M. Takahashi, K. Sato, P. Tas, J. He, M. Lecomte, T. Masuda, manuscript for *Pure Appl. Chem.*, (2002), 'Characterization and rheological properties of three polycarbonates with side-chain branching'.
- [78] M. Takahashi, K. Sakai, K. Sato, J. He, P. Tas, T. Masuda, manuscript for *Pure Appl. Chem.*, (2002), 'Processability and mechanical properties of three polycarbonates with side-chain branching'.
- [79] T. Kobatake, A. Yoshioka, K. Nakayama, J. He, Y. Aoki, T. Masuda, manuscript for *Pure Appl. Chem.* (2002), 'Structure and properties of hydrogenated acrylonitrile-butadiene rubber (HNBR). Part 1. Relation between viscosity and intermolecular interaction in dilute solution states'.
- [80] T. Kobatake, A. Yoshioka, K. Nakayama, J. He, Y. Aoki, T. Masuda, manuscript for *Pure Appl. Chem.* (2002), 'Structure and properties of hydrogenated acrylonitrile-butadiene rubber (HNBR). Part 2. Relation between viscosity and intermolecular interaction in condensed states'.

Appendix

Rules and codes of practice

1. Membership is free to all laboratories*) intending to participate activity in at least one of the projects. Active participation means: to make measurements and/or theory and to discuss them and to attend regularly the meetings dealing with the project(s) in which the member is participating.

Active new members are welcome to join the Working Party once they have attended a meeting as an observer, expressed their willingness to join the Working Party and abide by its rules, and are approved by the Working Party members present.

Full membership status shall be confirmed within 2 Working Party meetings by at least one attendance and active participation in at least one project. After two years from attending as an provisional member without taking part in a meeting and non-participation, the prospective member will be removed from the mailing list.

2. Members who are no longer able to participate actively are invited to resign from membership. No participation in a project for 2 years is deemed to be a mark of inactivity.
3. Each participating laboratory may delegate one or several members but correspondence will be preferably addressed to one member to be chosen by the laboratory, except by special request from a member laboratory.
4. Interim Reports and Final Reports will be sent by the author(s) to all participating members in a project with copies for the chairman and secretary.
5. All Working Party will receive a re-print of papers for publication.
6. Final reports to be published in Pure and Applied Chemistry (PAC) or any other scientific journal have to be submitted for approval to all members participating in the project, if possible after a general discussion during a Working Party meeting. An abstract of each final report will be prepared by the author(s) for publication in national and international journals in the field of polymers and plastics. In the abstract full reference will be given to the published final report.
7. A copy of mail concerning the Working Party exchanged between members should be sent to the secretary by the authors.
8. Working Party IV.2.1 convenes for a combined administrative and research meeting once a year. An additional research meeting may be convened but must be made open to any Working Party member. Such research meetings must be given approval by the Working Party chairman and secretary.
9. All communication is to be made electronically. It is a requirement of each member to make their current working e-mail address available and to check that this is current on the website. Details of all meetings will be distributed on the website. Alert messages from the secretary are to be sent out when important changes are made to the website.

* A laboratory can be interpreted as one of three things: an industrial laboratory, an institutional laboratory or the activities of an academic.

Table 1: Working Party Meetings between 1963 and 1980.

Meeting Number	Year	Venue	Chairman	Secretary
1	1963	London, UK	J. W. Barrett	-
2	1963	Brussels, Belgium	J. W. Barrett	-
3	1964	Delft, Holland	J. W. Barrett	-
4	1964	London, UK	J. W. Barrett	-
5	1965	Shawbury, UK	J. W. Barrett	-
6	1966	Brussels, Belgium	J. W. Barrett	S. Baxter
7	1966	Paris, France	J. W. Barrett	S. Baxter
8	1963	Delft, Holland	J. W. Barrett	S. Baxter
9	1967	London, UK	J. W. Barrett	S. Baxter
10	1967	Frankfurt, Germany	J. W. Barrett	S. Baxter
11	1967	Milan, Italy	J. W. Barrett	S. Baxter
12	1968	Brussels, Belgium	J. W. Barrett	S. Baxter
13	1968	London, UK	J. W. Barrett	S. Baxter
14	1968	Ludwigshafen, Germany	J. W. Barrett	S. Baxter
15	1969	Paris, France	J. W. Barrett	S. Baxter
16	1969	Prague, Czechoslovakia	A. J. de Vries	S. Baxter
17	1969	Strasbourg, France	A. J. de Vries	S. Baxter
18	1970	Delft, Holland	A. J. de Vries	S. Baxter
19	1971	Welwyn Garden City, UK	A. J. de Vries	M. E. Carrega
20	1971	Antony, France	A. J. de Vries	M. E. Carrega
21	1972	Bollate, Italy	A. J. de Vries	M. E. Carrega
22	1973	Frankfurt, Germany	A. J. de Vries	M. E. Carrega
23	1973	Aberdeen, Scotland	A. J. de Vries	M. E. Carrega
24	1974	Brussels, Belgium	A. J. de Vries	M. E. Carrega
25	1974	Ludwigshafen, Germany	A. J. de Vries	M. E. Carrega
26	1975	Paris, France	A. J. de Vries	M. E. Carrega
27	1975	Welwyn Garden City, UK	A. J. de Vries	M. E. Carrega
28	1976	Angera, Italy	A. J. de Vries	M. E. Carrega
29	1976	Amsterdam, Holland	P. L. Clegg	M. E. Carrega
30	1977	Brussels, Belgium	P. L. Clegg	M. E. Carrega
31	1977	Marl, Germany	P. L. Clegg	M. E. Carrega
32	1978	Frankfurt, Germany	P. L. Clegg	M. E. Carrega
33	1978	Welwyn Garden City, UK	P. L. Clegg	M. E. Carrega
34	1979	Noordwijkerhout, Holland	P. L. Clegg	M. E. Carrega
35	1979	Brussels, Belgium	P. L. Clegg	M. E. Carrega
36	1980	Barry, Wales	P. L. Clegg	M. E. Carrega
37	1980	Naples, Italy	P. L. Clegg	M. E. Carrega

Table 2: Working Party Meetings between 1981 and 2003. Names of the chairmen and secretaries of the East Asia Research Meetings (indicated by the letter A) are given in brackets.

Meeting Number	Year	Venue	Chairman	Secretary
38	1981	Paris, France	P. L. Clegg	M. E. Carrega
39	1981	Parkersburg, VA, USA	P. L. Clegg	M. E. Carrega
40	1982	Spetses, Greece	P. L. Clegg	M. E. Carrega
41	1983	Ludwigshafen, Germany	H. H. Meyer	D. R. Moore
42	1984	Delaware, USA	H. H. Meyer	D. R. Moore
43	1985	Dunblane, Scotland	H. H. Meyer	D. R. Moore
44	1986	Düsseldorf, Germany	H. H. Meyer	D. R. Moore
45	1987	Quebec, Canada	H. H. Meyer	D. R. Moore
46	1988	Cranfield, UK	H. H. Meyer	D. R. Moore
47	1989	Lille, France	D. R. Moore	H. M. Laun
48	1990	New York, USA	D. R. Moore	H. M. Laun
49	1991	Lagonisi, Greece	D. R. Moore	H. M. Laun
50	1992	Prague, Czechoslovakia	D. R. Moore	H. M. Laun
51	1993	Krakow, Poland	D. R. Moore	H. M. Laun
52	1994	Akron, USA	H. M. Laun	R. S. Bailey
53	1995	Amsterdam, Holland	H. M. Laun	R. S. Bailey
54	1996	Seoul, Korea	H. M. Laun	R. S. Bailey
54A	1996	Milan, Italy	H. M. Laun	R. S. Bailey
55	1997	Bodrum, Turkey	H. M. Laun	R. S. Bailey
55A	1997	Himeji, Japan	(T. Masuda)	-
56	1998	Hamburg-Harburg, Germany	H. M. Laun	R. S. Bailey
56A	1998	Kyoto, Japan	(T. Masuda)	-
57	1999	Les Diablerets, Switzerland	H. M. Laun	R. S. Bailey
57A	1999	Changchun, China	(T. Masuda)	-
58	2000	Lodz, Poland	H. M. Laun	R. S. Bailey
58A	2000	Taejon, Korea	(S. C. Kim)	(D. S. Lee)
59	2001	Karlsruhe, Germany	H. M. Laun	R. S. Bailey
59A	2001	Naha, Japan	(S. C. Kim)	(D. S. Lee)
60	2002	London (Ontario), Canada	H. M. Laun	R. S. Bailey
60A	2002	Beijing, China	(S. C. Kim)	(D. S. Lee)
60B	2003	Ludwigshafen, Germany	H. M. Laun	R. S. Bailey
61*)	2003	Stonefield Castle, Scotland	H. M. Laun	R. S. Bailey

*) 40th anniversary meeting