IMPACT

SAFETY FIRST

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Safety first

A multidisciplinary team of researchers who participated in the COST Action ***FLARETEX*** *is developing innovative and environmentally friendly flame retardants with low fire toxicity. In doing so, they are paving the way towards fire-safe, low toxic textiles and related materials*

Flame retardants (FRs) – chemicals added to many manufactured materials – are found everywhere. They play a key role in reducing the devastating impact of fires. However, not all FRs are environmentally sound and in the drive towards reducing negative environmental impacts, a number of FRs are being banned, or their use restricted. As a result, there is a need for innovative replacements that are not associated with health or environmental concerns, while still providing optimum fire safety benefits.

The recently completed COST Action FLARETEX (Sustainable flame retardancy for textiles and related materials based on nanoparticles substituting conventional chemicals) lasted four years and was headed up by Action Chair Professor Paul Kiekens, who is based at Ghent University in Belgium. Kiekens worked in close collaboration with Action Vice-Chair Professor Baljinder Kandola, Bolton University, UK, with valuable project administration by Els Van der Burght, who is also based at Ghent University.

STRENGTH IN NUMBERS

The goal behind FLARETEX was to form a European multidisciplinary Knowledge Platform on Sustainable Flame Retardancy to facilitate the rapid development of fire-safe textiles and related materials of low toxicity and ecotoxicity, using existing and novel technologies. The project was a highly multidisciplinary endeavour, connecting researchers from across different scientific disciplines and facilitating the exchange of knowledge and ideas, thereby promoting developments in fire safety, FRs and environmentally friendly fire-retarded textiles and related materials.

The different disciplines involved in FLARETEX included chemistry, materials science and engineering, physics, toxicology and medicine. As Kiekens explains, 'This multidisciplinary approach enabled a chain from new molecules to application of them in materials to be established, taking into account toxicity of structures, environmental impact, biomedical effects, (mathematical) modelling, standardisation, etc.'

There were an impressive number of contributors, with a total of 1094 participants from various research fields representing 55 countries having taken part in the scientific events organised by FLARETEX. Kiekens notes the importance of this cooperation and how research in this field hasn't always been collaborative: 'Several impressive research laboratories at academic level all over Europe have strong activity in flame retardancy. Most of these units work rather independently with a limited interaction at EU level. This lack of cooperation was felt as a real shortcoming in order to achieve cutting-edge breakthroughs in a reasonable time.' As Action Chair, it was Kiekens's responsibility to bring these different research units together, and in this role he drew on his extensive experience with European and international cooperation. He is undeniably pleased with what has been achieved through FLARETEX: 'Several exciting results have been achieved and they are the result of a strong cooperation not previously realised.'

UNITING ACROSS COUNTRIES AND DISCIPLINES

As well as uniting labs across Europe, FLARETEX welcomed industrial participation, which Kiekens reveals was somewhat unprecedented. 'This type of participation is unusual for this type of Action. This participation resulted in a strong exchange of knowledge between industry and academics which is really advantageous for all.'

In addition to connecting participants from academia and industry and thereby linking industry and academic research, FLARETEX had a wide reach in that it set out to address aspects related to technical, environmental, economic, medical and societal issues relating to the use of FRs. Activities were organised so that research was able to be coordinated on a European level. The researchers succeeded in establishing a repository of published research on FR textiles.

The project was organised into four sequential Working Groups (WGs): Novel Flame Retardants (WG1), Toxicological/Environmental Aspects (WG2), Processing/Applications/Commercialisation (WG3), and Testing/Standardisation (WG4). As part of WG1, new and environmentally friendly nano-based FR systems were explored, then in WG2 the FRs obtained in WG1 were investigated for their fire toxicity, ecotoxicological and environmental impacts. An analysis of the risks and benefits of using FRs in consumer products was also carried out. Next, in WG3, application processes were studied, developed and optimised and intensive cooperation with industrial partners was performed with a view to commercialising the best products and processes. Finally, in WG4 tests were performed to ensure the standardisation and safety of FR textiles.

‘Four years of intensive work have turned into a major step forward in all aspects of flame retardancy’

INTO THE UNKNOWN

The FLARETEX researchers extensively experimented with combining nanoparticles with conventional FRs. According to Kiekens, the introduction of nanoparticles to FRs hasn’t provided the results that were hoped for, and more research is required to reach concrete conclusions. ‘Some nanoparticles (nanoclays, expandable graphite particles) do have interesting effects but generally nanoparticles are not able to outperform conventional FRs,’ he explains. ‘An alternative approach is the use of nanoparticles in combination with newly developed compounds based on phosphorus or nitrogen (or phosphorus-nitrogen molecules) conferring flame retardancy.’ Kiekens believes that the introduction of new application technologies such as layer-by-layer or sol-gel technology may help to push the balance in favour of nanoparticles.

Although existing FRs are successful when it comes to efficiency, they are damaging to both health and the environment, and there is therefore a need to replace them with safer counterparts. However, this is problematic as it is challenging to find replacements that have the same or greater impact at the same or lower cost. The need to replace them, though, is becoming more pressing as more and more FRs are restricted or banned owing to their damaging effects.

IMPRESSIVE OUTPUTS

Kiekens is nevertheless extremely pleased with the project outputs: ‘Four years of intensive work have turned into a major step forward in all aspects of flame retardancy. Cooperation and multidisciplinarity were key to this success.’ Key outputs include progress in the development of new molecules to confer flame retardancy to textiles and related materials as alternatives for halogen-based FRs, the use of different nanoparticles, and the assessment of effects and new insights into the toxicity and mechanisms of flame retardancy. This is in addition to fruitful collaboration and the development of valuable knowledge on FRs that will have a significant impact on fire safety.

Examples of successful FLARETEX events and achievements

FLARETEX + RSC (Royal Society of Chemistry) Conference on Fire Retardant Technologies (FRT14) - 14–17 April 2014, Preston, UK. 190 participants (103 from industry). Resulted in a special issue of the open access journal *Polymer Degradation and Stability*, including 21 publications.

Industrial Workshop on ‘The Future of Flame Retardants – Materials & Systems’ - 8 May 2014, Dübendorf, Switzerland. 95 delegates from all over Europe (63 from industry).

Workshop on ‘Advances in Flame Retardancy of Polymeric Materials’ - 4–6 February 2015, Madrid, Spain. 116 participants (48 from non-COST countries).

Workshop on ‘Thermophysical Properties, Thermal Stability and Fire Retardancy of Blends and Filled Polymers’ - 29–30 April 2015, Montpellier, France. 94 participants. Resulted in a special issue of *Polymer Degradation and Stability*, including 12 papers.

After completion of the COST Action, a special COST MP1105 Issue on ‘Recent Advances in Flame Retardancy of Textile Related Products’ in the open access journal POLYMERS was published, containing 15 publications in the domain of flame retardancy, and supported by the COST Association.

Project Insights

FUNDING

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PARTICIPATING COUNTRIES

Austria • Belgium • Bulgaria • China • Croatia • Czech Republic • Denmark • Finland • France • Germany • Greece • Hungary • Israel • Italy • Latvia • Lithuania • Macedonia • The Netherlands • Poland • Portugal • Romania • Serbia • Slovakia • Slovenia • South Africa • Spain • Sweden • Switzerland • Turkey • United Kingdom

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Paul Kiekens is a Full Professor and Head of Department of Materials, Textiles and Chemical Engineering (MaTCh) at Ghent University, Belgium. He holds PhDs in physical chemistry and textile technology. He was Dean of the Faculty of Engineering and Architecture from 2002 to 2004 and is the Executive Coordinator of the Association of Universities for Textiles (AUTEX). Kiekens has been involved in national and European projects about education and research and has more than 200 international publications including several books.

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Impact Objectives

- Form a European multidisciplinary Knowledge Platform on Sustainable Flame Retardancy
- Facilitate the rapid development of fire-safe textiles and related materials of low toxicity and ecotoxicity

New contacts and know-how in flame retardants

***Professor Paul Kiekens** discusses how the far-reaching input of researchers worldwide contributed to the success of the innovative COST Action **FLARETEX**, which was designed to address the health and environmental concerns of flame retardants*

What is FLARETEX (Sustainable flame retardancy for textiles and related materials based on nanoparticles substituting conventional chemicals) and how did the project come about?

FLARETEX is the result of a need to work together in the area of flame retardancy, which was felt by many academic research laboratories all over Europe. This need resulted mainly from health and environmental concerns in several countries, including the EU's legislative framework on chemicals, such as the Regulation on Registration, Evaluation, Authorisation and Restriction on Chemicals (REACH). As many materials (e.g. textiles, composites, paper, plastics, etc.) are inherently flammable, injuries to people and property damage can have a high societal impact. Tackling these flame retardancy issues requires input from as many knowledge areas as possible. The COST programme is a strong instrument which makes such cooperation possible and therefore a COST Action was considered to be an adequate answer.

Can you describe your background and what led to your involvement in FLARETEX?

Being educated in physical chemistry and having extensive experience in textile and related materials, I could understand the urgent need for an extended research activity about flame retardancy. Consumers have to be protected from flammability of materials. This requires innovation that results in solutions favourable to all living creatures.

For you, what are the most exciting elements of FLARETEX?

Through FLARETEX, contacts with hundreds of researchers have been realised, not only at European level but also worldwide. Contacts have been intensified, strengthened and likely will last for many years to come. The large participation of industrial representatives (in total 366, representing more than 240 different companies) shows their strong interest in the new developments in the field of flame retardants (FRs) and indicates the need for new know-how developed by research organisations.

What will be the benefits of replacing existing FRs with environmentally friendly counterparts?

Research indicates that novel FRs will be based on phosphorus-nitrogen compounds. These compounds can be or are beneficial to the environment when (bio)macromolecules are applied such as chitosan, biomass (agricultural waste), castor oil, DNA from herring sperm and polyphosphazenes. In addition, these molecules may show extra benefits as some of them have antimicrobial and antistatic properties and are even water-repellent, and all with very reduced or no toxicity.

Were any of the objectives set out before the project began not fulfilled?

Almost all of the project objectives have been fulfilled and some objectives much more than originally planned. The strong participation of industry was remarkable and is rather unusual for COST Actions. Almost one-third of participants came from the industrial world. Another success was the gender aspect: the gender balance in the Management Committee was close to equal, as well as for the recipients of the Short-Term Scientific Mission (STSM) grants.

Could you provide details of some of the most exciting outputs of the project and describe their societal relevance?

The result that organic waste (biomass) can be applied to develop compounds with flame retardancy was particularly interesting. In addition, the effect of nanoparticles, alone or in combination with more straightforward chemical structures, provided a lot to think about concerning their effectiveness. The use of layer-by-layer technology and sol-gel systems as novel approaches to apply FRs was revealing. New insights in FR mechanisms and toxicological aspects of molecules also were very rewarding. Valuable knowledge was obtained about how in general chemical structures establish flame retardancy.

What are your next plans for FLARETEX?

FLARETEX brought together a very large number of people in a European multidisciplinary Knowledge Platform on Sustainable Flame Retardancy. Many non-Europeans have joined the events too. The aim is to continue exploring the network via conferences, projects, scientific cooperation, exchange of students, researchers, etc.