

## Sunday, June 5, 2022

#### ARRIVAL AND REGISTRATION

#### 2:30 PM REGISTRATION BEGINS

|         | LECTURE OFFICE  | ON!   |
|---------|---|-------|
|         | LECTURE SESSION CONTRACTOR OF THE PROPERTY OF |       |
|         | Session Chair: Jamie Grunlan, Texas A&M Unive   | rsity |
| 3:15 PM | OPENING REMARKS   |       |
| 3:30 PM | Alexander Morgan, University of Dayton Research Institute   |       |
|         | Studying Smoldering to Flaming Transition in Polyurethane Furniture   |       |
|         | Sub-Assemblies: Effects of Fabrics, Flame Retardants, and Material  |       |
|         | Туре  | 1     |
| 4:00 PM | Mauro Zammarano, NIST   | _     |
|         | Fire Barrier Fabrics in Upholstered Furniture: An Obvious Solution to One   |       |
|         | of the Most Enduring Problems in Fire Safety  | 2     |
| 4:30 PM | BREAK   |       |
| 4:45 PM | <u>Isaac T. Leventon</u> , NIST   |       |
|         | The NIST Material Flammability Database: Experimental Measurements  |       |
|         | for Fire Model Calibration and Validation   | 3     |
| 5:15 PM | Morgan C. Bruns, St. Mary's University  |       |
|         | Development of Automated Calibration Tools for Determining Fire   |       |
|         | Model Input Parameters  | 4     |
| 5:45 PM | <u>Natallia Safronava</u> , Federal Aviation Administration   |       |
|         | Microscale Combustion Calorimetry and Material Change Similarity  | 5     |
| 6:15 PM | WELCOME RECEPTION   |       |

## Monday, June 6, 2022

# 7:00 AM BREAKFAST I 7AM – 10 AM IN THE HOTEL'S ATRIUM

|         | LECTURE SESSION  | II NC |
|---------|--|-------|
|         | Session Chair: Alexander Morgan, University of Dayton Research Insti | itute |
| 8:30 AM | Anteneh Worku, Pinfa North America                                   |       |
|         | The Road to Flame Retardant Commercialization                        | 6     |
| 9:00 AM | <u>Sabyasachi Gaan</u> , EMPA, Switzerland                           |       |
|         | Hybrid Strategies for Improving the Fire Performance of Epoxy Resin  |       |
|         | Cured With Aliphatic Hardener  | 7     |
| 9:30 AM | <u>Svetlana Tretsiakova-McNally</u> , Ulster University, UK          |       |
|         | Thermal Decomposition of Styrenic Polymers Modified with Covalently  |       |
|         | Bound P- and N-containing Groups: Analysis of the Gaseous-Phase      |       |
|         | Mechanism  | 8     |



# Monday, June 6, 2022, cont'd

| 10:00 AM | BREAK   |       |
|----------|---|-------|
| 10:15 AM | <u>Todd Emrick</u> , University of Massachusetts – Amherst              |       |
|          | Designing Oligo- and Polymeric Flame Retardants for High Char Yields    | 9     |
| 10:45 AM | Sabine Fuchs, Hamm-Lippstadt University of Applied Science, Germany     |       |
|          | Halogen-Free Styrene Copolymers With Intrinsic Flame Retardant          |       |
|          | Properties  | 10    |
| 11:15 AM | Jacques A. De Beer, University of Maryland                              |       |
|          | Milligram-scale Flame Calorimetry: Development of a Pyrolyzer System    |       |
|          | used for Accurate Emulation of the Burning Behavior of Non-thermally    |       |
|          | Thin Samples  | 11    |
| 11:45 AM | END AM SESSION, LUNCH ON YOUR OWN                                       |       |
|          | LECTURE SESSIO  | N III |
| Sess     | ion Chair: Mauro Zammarano, National Institute of Standards and Technol | logy  |
| 4:00 PM  | Ramaswamy Nagarajan, University of Massachusetts Lowell                 |       |
|          | Surface functionalization Strategies for Fire Retardant Nylon, Cotton   |       |
|          | and, Nyco   | 12    |
| 4:30 PM  | Bernhard Schartel, BAM Federal Institute for Materials Research and     | _     |
|          | Testing, Germany  |       |
|          | Non-vegan Flame-Retardant (Adjuvants in) Biocomposites                  | 13    |
| 5:00 PM  | Helge-Otto Fabritius, Hamm-Lippstadt University of Applied Sciences,    |       |
|          | Germany   |       |
|          | Mechanistic Investigations of Wasp Nest Papers: Towards                 |       |
|          | Environmentally Compatible Flame-Retardant Concepts for Synthetic       |       |
|          | Materials   | 14    |
| 5:30 PM  | END DAILY LECTURES  |       |
| 6:00 PM  | POSTER SESSION  |       |
|          | END DAILY SESSIONS  |       |
|          |   |       |

## Tuesday, June 7, 2022

## 7:00 AM BREAKFAST I 7AM – 10 AM IN THE HOTEL'S ATRIUM

|         | LECTURE SESSI  | ON IV  |
|---------|--|--------|
|         | Session Chair: Sabyasachi Gaan, EMPA, Switze                     | erland |
| 8:30 AM | <u>Serge Bourbigot</u> , University of Lille, France             | _      |
|         | Recent Advances in Designing Fire Barriers                       | 15     |
| 9:00 AM | Jaime Grunlan, Texas A&M University                              |        |
|         | Water-Based, Environmentally-Benign, Polyelectrolyte-Based Flame |        |
|         | Retardant Treatments   | 16     |
| 9:30 AM | Severine Bellayer, University of Lille, France                   | _      |
|         | Formulation of Thin and Thick FR Sol-Gel Coatings                | 17     |



# Tuesday, June 7, 2022, cont'd

| 10:00 AM | BREAK  |      |
|----------|--|------|
| 10:15 AM | Ravi Mosurkal, US Army CCDC  |      |
|          | Surface Functionalization Strategies for Fire Retardant Nylon, Cotton, |      |
|          | and Nyco   | 18   |
| 10:45 AM | <u>Jeffrey Pyun</u> , University of Arizona                            |      |
|          | Polymers Derived From Elemental Sulfur with Enhanced                   |      |
|          | Thermomechanical and Flame Retardant Properties                        | 19   |
| 11:15 AM | Yury Brusentsev, Åbo Akademi University, Finland                       |      |
|          | Sulfenamides, Sulfinamides and Sulfonamides as Flame Retardants –      |      |
|          | Similarities and Differences in the Mechanism of Action                | 20   |
| 11:45 AM | END AM SESSION, LUNCH ON YOUR OWN                                      |      |
|          | LECTURE SESSI  | ON V |
|          | Session Chair: Serge Bourbigot, University of Lille, Fr                | ance |
| 4:00 PM  | Baljinder Kandola, University of Bolton, United Kingdom                |      |
|          | Effect of Crosslinkers on Charring Efficiency of Lignin-Polyamide      |      |
|          | Precursors for the Production of Carbon Fibers                         | 21   |
| 4:30 PM  | <u>Conor McCoy</u> , University of Maryland                            |      |
|          | Modeling of Flame Spread on Charring, Non-charring, and Flame          |      |
|          | Retardant Polymers In UL-94V   | 22   |
| 5:00 PM  | Lorenza Maddalena, Politecnico di Torino-Alessandria campus, Italy     |      |
|          | Water-Based Processes Exploiting High Aspect Ratio Nanoparticles for   |      |
|          | the Development of Flame Retardant Flexible Polyurethane Foams         | 23   |
| 5:30 PM  | BREAK  |      |
| 5:45 PM  | Vitus Hupp, Bundesanstalt für Materialforschung und -prüfung           |      |
|          | (BAM), Germany   |      |
|          | Adhesive Tapes in Bonded Materials - Fire Risk or Protective Layer?    | 24   |
| 6:15 PM  | Markus Wiesemann, Hamm-Lippstadt University of Applied                 |      |
|          | Sciences, Germany  |      |
|          | Halogen-Free Syntheses of Phosphoric Esters Based on Phosphorus        |      |
|          | Pentoxide  | 25   |
| 6:45 PM  | END DAILY SESSIONS   |      |
|          |  |      |

# Wednesday, June 8, 2022

7:00 AM BREAKFAST I 7AM – 10 AM IN THE HOTEL'S ATRIUM

|         | LECTURE SESSIO   | N VI  |
|---------|--|-------|
|         | Session Chair: Baljinder Kandola, University of Bolton       | ı, UK |
| 8:30 AM | Gaëlle Fontaine, University of Lille, France                 |       |
|         | Mechanistic Aspects of Flame Retarded Polybutylene Succinate | 26    |



# Wednesday, June 8, 2022, cont'd

| Thomas J. Kolibaba, NIST   |  |
|--|--|
| Polyelectrolyte Composites for Flame Retardant Additive              |  |
| Manufacturing  | 27   |
| <b>Igor Jordanov</b> , Ss. Cyril and Methodius University, Macedonia |  |
| Lignin-Based Multilayer Nanocoating for Flame Retardant Cotton       |  |
| Fabric   | 28   |
| BREAK  |  |
| Bob A. Howell, Central Michigan University                           |  |
| Iron Additives as Alternatives to Antimony Oxide in Flame-Retardant  |  |
| Formulations   | 29   |
| <u>Hatsuo Ishida</u> , Case Western Reserve University               |  |
| Polybenzoxazines: Development of Very High Performance               |  |
| Noncombustible Polymers without the Need of Flame Retarding          |  |
| Additives  | 30   |
| CLOSING REMARKS  |  |
|  | Igor Jordanov, Ss. Cyril and Methodius University, Macedonia Lignin-Based Multilayer Nanocoating for Flame Retardant Cotton Fabric BREAK Bob A. Howell, Central Michigan University Iron Additives as Alternatives to Antimony Oxide in Flame-Retardant Formulations Hatsuo Ishida, Case Western Reserve University Polybenzoxazines: Development of Very High Performance Noncombustible Polymers without the Need of Flame Retarding Additives |



# MONDAY, JUNE 6, 2022

| Manon Fleurotte, Abdenour Amokrane, Olivier Authier, Gérald Debenest, Gaëlle Fontaine, and Serge Bourbigot EDF RRD, University of Lille, CNRS, INRAE, FRANCE Sensitivity Analysis of the Pyrolysis Model of Non-Charring and Charring Materials Using Morris Screening Method Lei Chen, Byeongini Baek, Scott Corneillie, Cheryl Patchett, Amol Prabhakar Avhad, Swamy SM, Han Goossens, and Sreekanth Pannala SABIC Corporate Technology and Innovation, UNITED STATES Development of Computational Fluid Dynamics Models for Flame Retardant Thermoplastics in Electric Vehicle Applications James P. Covello, Erik J. Price, Rajib Paul, and Gary E. Wnek Case Western Reserve University, UNITED STATES Tannic Acid-based Super-Inturnescent Coatings for Prolonged Fire Protection of Cardboard and Wood Jacques A. De Beer, Joseph A. Alascio, Stanislav I, Stoliarov, Emily L. Dietz, Michael J., Gollner University of Maryland Analysis of Thermal Exposure and Ignition of Western Red Cedar Subject to Glowing Firebrand Piles Kata Enikő Decsov, Bettina Ötvös, Györay Marosi, and Katalin Bocz Budapest University of Technology and Economics, HUNGARY Development of Silica Microfibres and Application as Flame Retardant Additives in Poly(lactic acid) Michael V. Heck, Isaac T. Leventon*, Matthew F. Bundy, Kevin B. McGrattan, and Rick D. Davis NIST, UNITED STATES Experimental Measurements of Full-Scale Fire Growth for Fire Model Validation Carl-Christoph Höhne, Volker Gettwert, and Andreas Menrath Fraunhofer Institute for Chemical Technology ICT, GERMANY Flame Retardancy Investigations on Composites for Lightweight Electric Vehicle Battery Housings  David J. Irvin, Kousaalya Bakthavatchalam, Rahul Harkawat, and Jennifer A. Irvin Firesafe Zone LLC, UNITED STATES  Scale-Up and Testing of New Self-Extinguishing Polymer  Md Tahmid Islam, Gordon L. Nelson, and M. Toufiq Reza Florida Institute of Technology Combustion Kinetics of Hydrothermally Carbonized Lignocellulosic Biomass by Cone Calorimeter  Sourable Kulkarni, Julie St., Cyr, Zhiyu Xia, Arjan Giaya, Ryan B | POSTER PROGR   | AM  |
|--|--|-----|
| EDF R&D, University of Lille, CNRS, INRAE, FRANCE Sensitivity Analysis of the Pyrolysis Model of Non-Charring and Charring Materials Using Mornis Screening Method  Let Chen, Byeongjin Baek, Scott Corneillie, Cheryl Patchett, Amol Prabhakar Avhad, Swamy SM, Han Goossens, and Sreekanth Pannala SABIC Corporate Technology and Innovation, UNITED STATES 2 Development of Computational Fluid Dynamics Models for Flame Retardant Thermoplastics in Electric Vehicle Applications  James P. Covello, Erik J. Price, Rajib Paul, and Gary E. Wnek Case Western Reserve University, UNITED STATES Tannic Acid-based Super-Intumescent Coatings for Prolonged Fire Protection of Cardboard and Wood Jacaues A. De Beer, Joseph A. Alascio, Stanislav I. Stoliarov, Emily L. Dietz, Michael J. Gollner University of Maryland Analysis of Thermal Exposure and Ignition of Western Red Cedar Subject to Glowing Firebrand Piles  Kata Enilkő Decsov, Bettlina Ötvös, Gvöray Marosi, and Katalin Bocz Budapest University of Technology and Economics, HUNGARY Development of Silica Microfibres and Application as Flame Retardant Additives in Poly(lactic acid)  Michael V. Heck, Isaac T. Leventon*, Matthew F. Bundy, Kevin B. McGrattan, and Rick D. Davis NIST, UNITED STATES Experimental Measurements of Full-Scale Fire Growth for Fire Model Validation  Carl-Christoph Höhne, Volker Gettwert, and Andreas Menrath Fraunhofer Institute for Chemical Technology ICT, GERMANY Flame Retardancy Investigations on Composites for Lightweight Electric Vehicle Battery Housings  David J. Irvin, Kousaalya Bakthavatchalam, Rahul Harkawat, and Jennifer A. Irvin Firesafe Zone LLC, UNITED STATES Scale-Up and Testing of New Self-Extinguishing Polymer  Md Tahmid Islam, Gordon L. Nelson, and M. Toufig Reza Florida Institute of Technology Come Calorimeter  Sourabh Kulkarni, Julie St. Cyr., Zhiyu Xia, Arjan Giaya, Ryan Bouldin, Ravi Mosurkal, and Ramaswamy Nagarajan University of Massachusetts Lowell, UNITED STATES  Simple Surface Functionalization Method for Multifunctional Textiles with Flame  | Manon Fleurotte, <b>Abdenour Amokrane</b> , Olivier Authier, Gérald Debenest, Gaëlle   |     |
| Sensitivity Analysis of the Pyrolysis Model of Non-Charring and Charring Materials Using Morris Screening Method  Lei Chen, Byeongjin Baek, Scott Corneillie, Cheryl Patchett, Amol Prabhakar  Avhad, Swamy SM, Han Goossens, and Sreekanth Pannala  SABIC Corporate Technology and Innovation, UNITED STATES  Development of Computational Fluid Dynamics Models for Flame Retardant Thermoplastics in Electric Vehicle Applications  James P. Covello, Erik J. Price, Raiib Paul, and Gary E. Wnek  Case Western Reserve University, UNITED STATES  James P. Covello, Erik J. Price, Raiib Paul, and Gary E. Wnek  Case Western Reserve University, UNITED STATES  Jannic Acid-based Super-Inturnescent Coatings for Prolonged Fire Protection of Cardboard and Wood  Jacaues A. De Beer, Joseph A. Alascio, Stanislav I. Stoliarov, Emily L. Dietz, Michael J. Gollner  University of Maryland  Analysis of Thermal Exposure and Ignition of Western Red Cedar Subject to Glowing Firebrand Piles  Kata Enikő Decsov, Bettina Ötvös, Gvörgy Marosi, and Katalin Bocz  Budapest University of Technology and Economics, HUNGARY  Development of Silica Microfibres and Application as Flame Retardant Additives in Poly(lactic acid)  Michael V. Heck, Isaac T. Leventon*, Matthew F. Bundy, Kevin B. McGrattan, and Rick D. Davis  NIST, UNITED STATES  Experimental Measurements of Full-Scale Fire Growth for Fire Model Validation  Carl-Christoph Höhne, Volker Gettwert, and Andreas Menrath  Fraunhofer Institute for Chemical Technology ICT, GERMANY  Flame Retardancy Investigations on Composites for Lightweight Electric Vehicle Battery Housings  David J. Irvin, Kousaalya Bakthavatchalam, Rahul Harkawat, and Jennifer A. Irvin Firesafe Zone LLC, UNITED STATES  Scale-Up and Testing of New Self-Extinguishing Polymer  Md Tahmid Islam, Gordon L. Nelson, and M. Toufia Reza  Florida Institute of Technology  Combustion Kinetics of Hydrothermally Carbonized Lignocellulosic Biomass by Cone Calorimeter  Sourabh Kulkarni, Julie St. Cyr., Thiyu Xia, Arian Giaya, Ryan Bouldin, Ravi Mosurkal, and  | <u>Fontaine</u> , and <u>Serge Bourbigot</u>   |     |
| Using Morris Screening Method         Lei Chen, Byeongjin Baek, Scott Corneillie, Cheryl Patchett, Amol Prabhakar           Avhad, Swamy SM, Han Goossens, and Sreekanth Pannala         SABIC Corporate Technology and Innovation, UNITED STATES         2           Development of Computational Fluid Dynamics Models for Flame Retardant Thermoplastics in Electric Vehicle Applications         James P. Covello, Erik J. Price. Rajib Paul, and Gary E. Wnek         3           Case Western Reserve University, UNITED STATES         Tannic Acid-based Super-Intumescent Coatings for Prolonged Fire Protection of Cardboard and Wood         4           Jacaues A. De Beer, Joseph A. Alascio, Stanislav I, Stoliarov, Emily L. Dietz, Michael J. Gallner         4           University of Maryland         4           Analysis of Thermal Exposure and Ignition of Western Red Cedar Subject to Glowing Firebrand Piles         4           Kata Enikő Decsov, Bettina Ötvös, Gvörgy Marosi, and Katalin Bocz         5           Budapest University of Technology and Economics, HUNGARY         5           Development of Silica Microfibres and Application as Flame Retardant Additives in Poly(lactic acid)         5           Michael V, Heck, Isaac T, Leventon*, Matthew F, Bundy, Kevin B, McGrattan, and Rick D. Davis         6           NIST, UNITED STATES         Experimental Measurements of Full-Scale Fire Growth for Fire Model Validation           Carl-Christoph Höhne, Volker Gettwert, and Andreas Menrath         6           Flame Retardancy Investigati  | EDF R&D, University of Lille, CNRS, INRAE, FRANCE                                      | 1   |
| Lei Chen, Byeongiin Baek, Scott Corneillie, Cheryl Patchett, Amol Prabhakar         Avhad, Swarmy SM, Han Goossens, and Sreekanth Pannala         SABIC Corporate Technology and Innovation, UNITED STATES         Development of Computational Fluid Dynamics Models for Flame Retardant Thermoplastics in Electric Vehicle Applications         James P. Covello, Erik J. Price, Rajib Paul, and Gary E. Wnek         Case Western Reserve University, UNITED STATES         Tannic Acid-based Super-Intumescent Coatings for Prolonged Fire Protection of Cardboard and Wood         Jacques A. De Beer, Joseph A. Alascio, Stanislav I. Stoliarov, Emily L. Dietz, Michael J. Gollner         University of Maryland       4         Analysis of Thermal Exposure and Ignition of Western Red Cedar Subject to Glowing Firebrand Piles       6         Kata Enilkő Decsov, Bettina Ötvös, Györay Marosi, and Katalin Bocz       4         Budapest University of Technology and Economics, HUNGARY       5         Development of Silica Microfibres and Application as Flame Retardant Additives in Poly(lactic acid)       5         Michael V. Heck, Isaac T. Leventon*, Matthew F. Bundy, Kevin B. McGrattan, and Rick D. Davis       6         NIST, UNITED STATES       5         Experimental Measurements of Full-Scale Fire Growth for Fire Model Validation         Carl-Christoph Höhne, Volker Gettwert, and Andreas Menrath       6         Frame Retardancy Investigations on Composites for Lightweight Electric Vehicle Battery Housings<  | Sensitivity Analysis of the Pyrolysis Model of Non-Charring and Charring Materials     |     |
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| Thermoplastics in Electric Vehicle Applications  James P. Covello, Erik J. Price, Rajib Paul, and Gary E. Wnek  Case Western Reserve University, UNITED STATES  Tannic Acid-based Super-Intumescent Coatings for Prolonged Fire Protection of Cardboard and Wood  Jacques A. De Beer, Joseph A. Alascio, Stanislav I, Stoliarov, Emily L. Dietz, Michael J. Gollner  University of Maryland  Analysis of Thermal Exposure and Ignition of Western Red Cedar Subject to Glowing Firebrand Piles  Kata Enikő Decsov, Bettina Ötvös, György Marosi, and Katalin Bocz  Budapest University of Technology and Economics, HUNGARY  Development of Silica Microfibres and Application as Flame Retardant Additives in Poly(lactic acid)  Michael V. Heck, Isaac T. Leventon*, Matthew F. Bundy, Kevin B. McGrattan, and Rick D. Davis  NIST, UNITED STATES  Experimental Measurements of Full-Scale Fire Growth for Fire Model Validation  Carl-Christoph Höhne, Volker Gettwert, and Andreas Menrath  Fraunhofer Institute for Chemical Technology ICT, GERMANY  Flame Retardancy Investigations on Composites for Lightweight Electric Vehicle  Battery Housings  David J. Irvin, Kousaalya Bakthavatchalam, Rahul Harkawat, and Jennifer A. Irvin  Firesafe Zone LLC, UNITED STATES  Scale-Up and Testing of New Self-Extinguishing Polymer  Md Tahmid Islam, Gordon L. Nelson, and M. Toufiq Reza  Florida Institute of Technology  Combustion Kinetics of Hydrothermally Carbonized Lignocellulosic Biomass by  Cone Calorimeter  Sourabh Kulkarni, Julie St, Cyr, Zhiyu Xia, Arjan Giaya, Ryan Bouldin, Ravi Mosurkal, and Ramaswamy Nagarajan  University of Massachusetts Lowell, UNITED STATES  Simple Surface Functionalization Method for Multifunctional Textiles with Flame  | SABIC Corporate Technology and Innovation, UNITED STATES                               | 2   |
| James P. Covello, Erik J. Price, Rajib Paul, and Gary E. Wnek   Case Western Reserve University, UNITED STATES   Tannic Acid-based Super-Intumescent Coatings for Prolonged Fire Protection of Cardboard and Wood   Jacques A. De Beer, Joseph A. Alascio, Stanislav I. Stoliarov, Emily L. Dietz, Michael J. Gollner   University of Maryland   Analysis of Thermal Exposure and Ignition of Western Red Cedar Subject to Glowing Firebrand Piles   Kata Enikő Decsov, Bettina Ötvös, György Marosi, and Katalin Bocz   Budapest University of Technology and Economics, HUNGARY   Development of Silica Microfibres and Application as Flame Retardant Additives in Poly(lactic acid)   Michael V. Heck, Isaac T. Leventon*, Matthew F. Bundy, Kevin B. McGrattan, and Rick D. Davis   NIST, UNITED STATES   Steperimental Measurements of Full-Scale Fire Growth for Fire Model Validation   Carl-Christoph Höhne, Volker Gettwert, and Andreas Menrath   Fraunhofer Institute for Chemical Technology ICT, GERMANY   Flame Retardancy Investigations on Composites for Lightweight Electric Vehicle Battery Housings   Powid J. Irvin, Kousaalya Bakthavatchalam, Rahul Harkawat, and Jennifer A. Irvin   Firesafe Zone LLC, UNITED STATES   Scale-Up and Testing of New Self-Extinguishing Polymer   Md Tahmid Islam, Gordon L. Nelson, and M. Toufig Reza   Florida Institute of Technology   Combustion Kinetics of Hydrothermally Carbonized Lignocellulosic Biomass by   Cone Calorimeter   Sourabh Kulkarni, Julie St. Cyr, Zhiyu Xia, Arjan Giaya, Ryan Bouldin, Ravi Mosurkal, and Ramaswamy Nagarajan   University of Massachusetts Lowell, UNITED STATES   Simple Surface Functionalization Method for Multifunctional Textiles with Flame   Analysis of Protection   Protectionalization Method for Multifunctional Textiles with Flame   Protectionalization Method for Multifunctional Textiles with Flame   Protectionalization Method for Multifunctional Textiles with Flame   Protectional Protectional Protectional Protectional Protectional Protectional Protectional Protectional Protectional Prot   | Development of Computational Fluid Dynamics Models for Flame Retardant                 |     |
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