

Organized by:  
**University of Zagreb**  
**Faculty of Textile Technology**



**ITC  
& DC**

# **BOOK OF PROCEEDINGS**

of the 9<sup>th</sup> International Textile, Clothing & Design Conference

## **Magic World of Textiles**

**Dubrovnik, CROATIA**  
**October 7<sup>th</sup> to October 10<sup>th</sup>, 2018**





9<sup>th</sup> INTERNATIONAL TEXTILE CLOTHING & DESIGN CONFERENCE  
October 7<sup>th</sup> to October 10<sup>th</sup>, 2018, Dubrovnik, CROATIA

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Organized by:  
**University of Zagreb**  
**Faculty of Textile Technology**  
**Zagreb, CROATIA**

Co-organiser:  
**Competitiveness Clusters Textile, Leather Goods and Footwear Industry**



Under the Auspices of:



MINISTRY OF SCIENCE,  
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The proceedings of the International Textile Clothing and Design Conference have been indexed in the Conference Proceedings Citation Index- Science (CPCI-S), while a selection of the papers from the 9<sup>th</sup> ITC&DC 2018 will be published in the following publications: International Journal of Clothing Science and Technology (ISSN 0955-6222), Kemija u industriji (ISSN 0022-9830) and Tekstil (ISSN 0492-5882).

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## PREFACE

Dear colleagues, dear friends!

The Faculty of Textile Technology, University of Zagreb, has organised the 9<sup>th</sup> International Textile, Clothing and Design Conference – **Magic World of Textiles**, making this conference a traditional one.

Our big ITC&DC family has grown through eight ITC&DC conferences organised up to now, and it includes more

than 2858 authors with 1277 papers from 38 countries of Europe and all over the world. As every decent family, we have found, thanks to the hospitality of the Centre for Advanced Academic Studies (CAAS), our home here in Dubrovnik. Beside this, there are a lot of other reasons why the ITC&DC is organised in Dubrovnik. Historically speaking, at the time of the Dubrovnik Republic (from the early Middle Ages to the time of the Napoleonic Wars) the ships of the Republic sailed world-wide, and Dubrovnik even had its colonies (like Goya in India). The part of the town called Pile, where our Conference is held, used to be the centre of textiles in the Dubrovnik Republic, while the peasants in the nearby Konavosko polje reared silkworms and produced silk until the mid-nineteenth century. Dubrovnik is also a city of exceptional cultural and historical monuments and is included in the UNESCO World Heritage List. It is also a city with a millennium (or almost two millennia) history, where everybody can find his/her true self.

I would like to express my warm welcome to all of you in Dubrovnik! I am personally grateful to all the colleagues who attended previous ITC&DC for coming again to the beautiful town of Dubrovnik. However, I am sincerely happy for those who are here in Dubrovnik and Croatia for the first time.

Of all the papers received this year, the members of the International Reviewer Committee have accepted 64 papers for the 9<sup>th</sup> ITC&DC and 59 of them are published in this Book of Proceedings. I would like to express my sincerest thanks to all the participants for their valuable contribution and readiness to spend a part of their time in Dubrovnik, making the picture of the Magic World of Textiles more valuable and more real.

My special thanks go to the Croatian Ministry of Science, as well as to the international scientific associations that have accepted to be the patrons of the conference, proving it to be necessary, justified and useful. My gratitude also goes to all the individuals and institutions that have helped us organise the 9<sup>th</sup> ITC&DC.



Edita VUJASINOVIĆ

## Final report for ITC&DC Conferences – Magic World of Textiles

### 1<sup>st</sup> ITC&DC 2002

<i>Date &amp; Place</i>	October 6-9 <sup>th</sup> 2002, Dubrovnik, Croatia
<i>Under the Auspices</i>	DAAAM International, Vienna, Austria; AUTEX, Ghent, Belgium; The Textile Institute, Manchester, United Kingdom; The International Textile Academy New Delhi, India; University of Zagreb, Zagreb, Croatia; Croatian Academy of Engineering, Zagreb, Croatia
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<i>Plenary lecture</i>	Branko KATALINIĆ: Technical Product as Materialisation of Engineers Idea and Design Strategy of Nature
<i>Publication</i>	Book of Proceedings of the International Textile, Clothing & Design Conference, ISBN 953-96408-8-1
<i>Editor</i>	Zvonko Dragčević
<i>Publisher</i>	University of Zagreb, Faculty of Textile Technology, Zagreb, Croatia
<i>Authors / Papers</i>	239 / 129
<i>Number of Countries Participants came from</i>	26
<i>Referred /Indexed in</i>	Conference Proceedings Citation Index – Science (CPCI-S), World Textile Abstracts, Textile Technology Digest, Textile Global/Net, Chemical Abstracts
<i>Selected Papers published in Journals after Conference</i>	International Journal of Clothing Science and Technology, <b>15</b> (2003) 3/4, (ISSN 0955-6222)
<i>Organising Committee</i>	Z. Dragčević – president, N. Vuljanić – vice president, D. Grundler, A. Hursa, N. Krmpotić, T. Rolich, D. Rogale, E. Vujasinović

### 2<sup>nd</sup> ITC&DC 2004

<i>Date &amp; Place</i>	October 3-6 <sup>th</sup> 2004, Dubrovnik, Croatia
<i>Under the Auspices</i>	Ministry of Science, Education and Sport, Zagreb, Croatia; University of Zagreb, Zagreb, Croatia; Ministry of Economy, Labour and Entrepreneurship, Zagreb, Croatia; Croatian Chamber of Economy, Zagreb, Croatia; DAAAM International, Vienna, Austria; AUTEX, Ghent, Belgium; The Textile Institute, Manchester, United Kingdom; The International Textile Academy New Delhi, India; Croatian Academy of Engineering, Zagreb, Croatia; Croatian Society of Chemical Engineers, Zagreb, Croatia
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<i>Plenary lecture</i>	George K. STYLIOS: New Measurement Technologies for Textiles and Clothing
<i>Publication</i>	Book of Proceedings of the 2 <sup>nd</sup> International Textile, Clothing & Design Conference, ISBN 953-7105-05-9
<i>Editor</i>	Zvonko Dragčević
<i>Publisher</i>	University of Zagreb, Faculty of Textile Technology, Zagreb, Croatia
<i>ISBN</i>	953-7105-05-9
<i>Authors / Papers</i>	352 / 180
<i>Number of Countries Participants came from</i>	29
<i>Referred /Indexed in</i>	Conference Proceedings Citation Index – Science (CPCI-S), World Textile Abstracts, Textile Technology Digest, Textile Global/Net, Chemical Abstracts
<i>Selected Papers published in Journals after Conference</i>	International Journal of Clothing Science and Technology, <b>17</b> (2005) 3/4, (ISSN -955-6222)
<i>Organising Committee</i>	Z. Dragčević – president, N. Vuljanić – vice president, A. Hursa, N. Krmpotić, B. Mauser, I. Petrunić, T. Rolich, E. Vujasinović

### 3<sup>rd</sup> ITC&DC 2006

<i>Date &amp; Place</i>	October 8-11 <sup>th</sup> 2006, Dubrovnik, Croatia
<i>Under the Auspices</i>	Ministry of Science, Education and Sport, Zagreb, Croatia; University of Zagreb, Zagreb, Croatia; Ministry of Economy, Labour and Entrepreneurship, Zagreb, Croatia; Croatian Academy of Engineering, Zagreb, Croatia; DAAAM International, Vienna, Austria; AUTEX, Ghent, Belgium; The Textile Institute, Manchester, United Kingdom; The International Textile Academy New Delhi, India; American Association of Textile Chemists and Colorists, Research Triangle Park, United States of America; Croatian Society of Chemical Engineers, Zagreb, Croatia; International Federation of Knitting Technologists, Reutlingen, Germany; Croatian Chamber of Economy, Zagreb, Croatia; INA Oil Industry, Zagreb, Croatia; City of Dubrovnik, Croatia
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<i>Plenary lecture</i>	Eckhard SCHOLLMAYER: Nanotechnology for Functionalization of Textile Materials
<i>Publication</i>	Book of Proceedings of the 3 <sup>rd</sup> International Textile, Clothing & Design Conference, ISBN 953-7105-12-1
<i>Editor</i>	Zvonko Dragčević
<i>Publisher</i>	University of Zagreb, Faculty of Textile Technology Zagreb, Croatia
<i>ISBN</i>	953-7105-12-1
<i>Authors / Papers</i>	414 / 183
<i>Number of Countries Participants came from</i>	31

<i>Referred /Indexed in</i>	Conference Proceedings Citation Index – Science (CPCI-S), World Textile Abstracts, Textile Technology Digest, Textile Global/Net, Chemical Abstracts
<i>Selected Papers published in Journals after Conference</i>	International Journal of Clothing Science and Technology, <b>19</b> (2007) 3/4, (ISSN 0955-6222), Kemija u industriji, <b>56</b> (2007) 11, (ISSN 0022-9830), Tekstil <b>56</b> (2007) 2, (ISSN 0492-5882)
<i>Organising Committee</i>	Z. Dragčević – president, N. Vuljanić – vice president, M. Bobovčan, S. Bogović, I. Geratović, A. Hursa, Đ. Jandrić, M. Martek, K. Matušić, B. Mauser, I. Petrunić, E. Vujasinović

**4<sup>th</sup> ITC&DC 2008**

<i>Date &amp; Place</i>	October 5-8 <sup>th</sup> 2008, Dubrovnik, Croatia
<i>Under the Auspices</i>	Ministry of Science, Education and Sport, Zagreb, Croatia; University of Zagreb, Zagreb, Croatia; Croatian Chamber of Economy, Zagreb, Croatia; Croatian Academy of Engineering, Zagreb, Croatia; DAAAM International, Vienna, Austria; AUTEX, Ghent, Belgium; The Textile Institute, Manchester, United Kingdom; The International Textile Academy New Delhi, India; Society of Dyers and Colourists, Bradford, United Kingdom; Croatian Society of Chemical Engineers, Zagreb, Croatia; INA Oil Industry, Zagreb, Croatia
<i>Scientific Committee</i>	I. Soljačić (HR) – president; D. C. Adolphe (FR), M. Akalin (TR), M. Duarte de Araujo (PT), A. Curteza (RO), K. Dimitrovski (SI), Z. Dragčević (HR), J. Geršak (SI), B. Katalinić (AT), I. Krucinska (PL), S. Kukle (LV), A.V. Kulichenko (RU), A. Marcincin (SK), H. Mattila (FI), J. Militky (CZ), R. Postle (AU), H. Rödel (DE), E. Schollmeyer (DE), N. Starszakowna (GB), G. Stylios (GB), X. Tao (CN), D. Ujević (HR), L. Wadsworth (US), C. Q. Yang (US).
<i>Plenary lecture</i>	Charles Q. YANG: New Development in Functional Finishing and Cotton Textiles
<i>Publication</i>	Book of Proceedings of the 4 <sup>th</sup> International Textile, Clothing & Design Conference, ISBN 978-953-7105-26-6
<i>Editor</i>	Zvonko Dragčević
<i>Publisher</i>	University of Zagreb, Faculty of Textile Technology, Zagreb, Croatia
<i>ISBN</i>	978-953-7105-26-6
<i>Authors / Papers</i>	438 / 200
<i>Number of Countries Participants came from</i>	34
<i>Referred /Indexed in</i>	Conference Proceedings Citation Index – Science (CPCI-S), World Textile Abstracts, Textile Technology Digest, Textile Global/Net, Chemical Abstracts
<i>Organising Committee</i>	Z. Dragčević – president, N. Vuljanić – vice president, S. Bogović, A. Hursa, B. Mauser, M. Runkas, N.K. Simončić, E. Vujasinović

**5<sup>th</sup> ITC&DC 2010**

<i>Date &amp; Place</i>	October 3-6 <sup>th</sup> 2010, Dubrovnik, Croatia
<i>Under the Auspices</i>	President of the Republic of Croatia Prof. Ivo Josipović, Ph.D.; Ministry of Science, Education and Sport, Zagreb, Croatia; University of Zagreb, Zagreb, Croatia; Croatian Chamber of Economy, Zagreb, Croatia; Croatian Academy of Engineering, Zagreb, Croatia; DAAAM International, Vienna, Austria; AUTEX, Ghent, Belgium; Croatian Society

	of Chemical Engineers, Zagreb, Croatia; American Association of Textile Chemists and Colorists, Research Triangle Park, United States of America; International Federation of Knitting Technologists, Reutlingen, Germany; ESCORENA Poznan, Poland; CARNet, Zagreb, Croatia
<i>Scientific Committee</i>	I. Soljačić (HR) – president; D. C. Adolphe (FR), M. Duarte de Araujo (PT), A. Bjeliš (HR), H.J. Buschmann (DE), A. Curteza (RO), K. Dimitrovski (SI), Z. Dragčević (HR), J. Geršak (SI), R. Horrocks (GB), H. Kadoglu (TR), B. Katalinić (AT), R.M. Kozłowski (PL), S. Kukle (LV), A.V. Kulichenko (RU), R. Laing (NZ), A. Marcincin (SK), H. Mattila (FI), J. Militky (CZ), R. Postle (AU), N. Starszakowna (GB), G. Stylios (GB), X. Tao (CN), D. Ujević (HR), S.G. Vassiliadis (GR), X. Wang (AU), C. Q. Yang (US).
<i>Plenary lecture</i>	Dubravko ROGALÉ: Research and Development of Article of Clothing with Adaptive Mikroklimatic States
<i>Publication</i>	Book of Proceedings of the 5 <sup>th</sup> International Textile, Clothing & Design Conference, ISSN 1847-7275 [Book proc. (Int. text. cloth. des. conf.)]
<i>Editors</i>	Zvonko Dragčević, Anica Hursa Šajatović, Edita Vujasinović
<i>Publisher</i>	University of Zagreb, Faculty of Textile Technology, Zagreb, Croatia
<i>Authors / Papers</i>	423 / 168
<i>Number of Countries Participants came from</i>	36
<i>Referred /Indexed in</i>	Conference Proceedings Citation Index – Science (CPCI-S)
<i>Selected Papers published in Journals after Conference</i>	Tekstil, <b>59</b> (2010) 12, (ISSN 0492-5882)
<i>Organising Committee</i>	Z. Dragčević – president, N. Vuljanić – vice president, A. Hursa Šajatović, Z. Kovačević, B. Mauser, B. Šaravanja, T. Tisaj, S. Vlatković, E. Vujasinović

## 6<sup>th</sup> ITC&DC 2012

<i>Date &amp; Place</i>	October 7-10 <sup>th</sup> 2012, Dubrovnik, Croatia
<i>Under the Auspices</i>	Ministry of Science, Education and Sport, Zagreb, Croatia; University of Zagreb, Zagreb, Croatia; Croatian Academy of Engineering, Zagreb, Croatia; Croatian Chamber of Economy, Zagreb, Croatia; Ministry of Entrepreneurship and Trade, Zagreb, Croatia; DAAAM International, Vienna, Austria; AUTEX, Ghent, Belgium; American Association of Textile Chemists and Colorists, Research Triangle Park, United States of America; ESCORENA Poznan, Poland; International Federation of Knitting Technologists, Reutlingen, Germany; Croatian Society of Chemical Engineers, Zagreb, Croatia; Croatian Association of Textile Engineers, Zagreb, Croatia; International Technical Committee for Textile Care; Croatian Zeolite Association, Zagreb, Croatia; CARNet, Zagreb, Croatia
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<i>Plenary lecture</i>	Ron POSTLE: Mechanics and Physics of Soft Matter: Knitted Fabrics

<i>Publication</i>	Book of Proceedings of the 6 <sup>th</sup> International Textile, Clothing & Design Conference, ISSN 1847-7275 [Book proc. (Int. text. cloth. des. conf.)]
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<i>Publisher</i>	University of Zagreb, Faculty of Textile Technology, Zagreb, Croatia
<i>Authors / Papers</i>	275 / 125
<i>Number of Countries Participants came from</i>	34
<i>Referred /Indexed in</i>	Conference Proceedings Citation Index – Science (CPCI-S)
<i>Selected Papers published in Journals after Conference</i>	Tekstil, <b>61</b> (2012) 7-12, (ISSN 0492-5882)
<i>Organising Committee</i>	Z. Dragčević – president, N. Vuljanić – vice president, M. Bobovčan Marčelić, A. Hursa Šajatović, Z. Kovačević, I. Matijević, B. Mauser, B. Šaravanja, E. Vujasinović

### 7<sup>th</sup> ITC&DC 2014

<i>Date &amp; Place</i>	October 5-8 <sup>th</sup> 2014, Dubrovnik, Croatia
<i>Under the Auspices</i>	Ministry of Science, Education and Sport, Zagreb, Croatia; University of Zagreb, Zagreb, Croatia; Croatian Academy of Engineering, Zagreb, Croatia; Ministry of Economy, Zagreb, Croatia; DAAAM International, Vienna, Austria; AUTEX, Ghent, Belgium; American Association of Textile Chemists and Colorists, Research Triangle Park, United States of America; ESCORENA Poznan, Poland; International Federation of Knitting Technologists, Reutlingen, Germany; Croatian Society of Chemical Engineers, Zagreb, Croatia; Croatian Association of Textile Engineers, Zagreb, Croatia; CARNet, Zagreb, Croatia
<i>Scientific Committee</i>	I. Soljačić (HR) – president; D. C. Adolphe (FR), S. Bischof (HR), H.J. Buschmann (DE), A. Curteza (RO), K. Dimitrovski (SI), Z. Dragčević (HR), F.B.N. Ferreira (PT), J. Geršak (SI), J.W.S. Hearle (UK), H. Kadoglu (TR), B. Katalinić (AT), R.M. Kozłowski (PL), S. Kukle (LV), A.V. Kulichenko (RU), R. Laing (NZ), H. Mattila (FI), R. Milašius (LT), J. Militky (CZ), M. Neznakomova (BG), P. Al Pscheid (ID), R. Postle (AU), A. Ujhelyiova (SK), N. Starszakowna (GB), G. Stylios (GB), X. Tao (CN), S.G. Vassiliadis (GR), C. Q. Yang (US).
<i>Plenary lecture</i>	John W.S. HEARLE: From Calculators to 21st Century Computing: Successes and Opportunities in Digital Technology for the Textiles
<i>Publication</i>	Book of Proceedings of the 7 <sup>th</sup> International Textile, Clothing & Design Conference, ISSN 1847-7275 [Book proc. (Int. text. cloth. des. conf.)]
<i>Editors</i>	Zvonko Dragčević, Anica Hursa Šajatović, Edita Vujasinović
<i>Publisher</i>	University of Zagreb, Faculty of Textile Technology, Zagreb, Croatia
<i>Authors / Papers</i>	265 / 116
<i>Number of Countries Participants came from</i>	29
<i>Referred /Indexed in</i>	Conference Proceedings Citation Index – Science (CPCI-S)
<i>Selected Papers published in Journals after Conference</i>	Tekstil, <b>63</b> (2014) 11-12, (ISSN 0492-5882)
<i>Organising Committee</i>	Z. Dragčević – president, N. Vuljanić – vice president, A. Hursa Šajatović, B. Mauser, M. Pavunc, B. Šaravanja, T. Šimunić, I. Špelić, E. Vujasinović

**8<sup>th</sup> ITC&DC 2016**

<i>Date &amp; Place</i>	October 2-5 <sup>th</sup> 2016, Dubrovnik, Croatia
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