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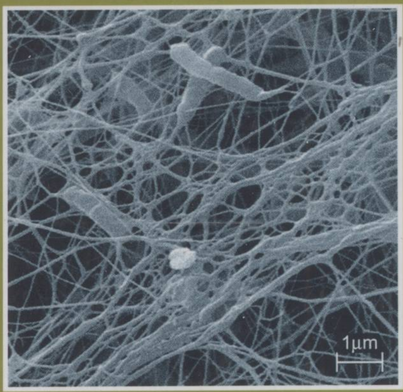


# Properties and performance of natural-fibre composites

Edited by Kim L. Pickering

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# Properties and performance of natural-fibre composites

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# Contributor contact details

(* = main contact)

**Editor and Introduction**
Dr K.L. Pickering
Department of Engineering
University of Waikato
Private Bag 3105
Hamilton
New Zealand
E-mail: klp@waikato.ac.nz

**Chapter 1**
Professor R.M. Rowell
Biological Systems Engineering Department
University of Wisconsin
Madison, WI 53706
USA
E-mail: rmrowell@wisc.edu

**Chapter 2**
Professor S. Thomas*
School of Chemical Sciences
Mahatma Gandhi University
Priyadarshini Hills P O
Kottayam
Kerala-686560
India
E-mail: sabut552001@yahoo.com

Dr P.A. Sreekumar
National Institute of Technology Calicut
NITC P O
Calicut
Kerala-673601
India

**Chapter 3**
Professor Dr N. E. Zafeiropoulos
Department of Materials Science and Engineering
School of Science and Technology
University of Ioannina
University Campus
GR-45110
Ioannina
Greece
E-mail: zafeiropoulos@gmail.com

**Chapter 4**
Professor Dr A.K. Bledzki*, A. Jaszkiewicz, M. Murr and Dr V.E. Sperber
Institut für Werkstofftechnik (IfW)
University of Kassel
Mönchebergstraße 3
34109 Kassel
Germany
E-mail: kutech@uni-kassel.de

Dr R. Lützkendorf and
Dr T. Reußmann
Thüringisches Institut für Textil- und Kunststoff-Forschung (TITK)
Breitscheidstraße 97
07407 Rudolstadt
Germany

**Chapter 5**

Dr R.H. Newman
Scion
Private Bag 3020 Rotorua Mail Centre
Rotorua 3046
New Zealand
E-mail:
roger.newman@scionresearch.com

**Chapter 6**

Dr R.H. Newman*
Scion
Private Bag 3020 Rotorua Mail Centre
Rotorua 3046
New Zealand
E-mail:
roger.newman@scionresearch.com

Dr M.P. Staiger
Department of Mechanical Engineering
University of Canterbury
Christchurch
New Zealand
E-mail:
mark.staiger@canterbury.ac.nz

**Chapter 7**

M. S. Huda and L.T. Drzal
Composite Materials and Structures Center
2100 Engineering Building
Michigan State University
East Lansing, MI 48824
USA
E-mail: drzal@egr.msu.edu
huda965@yahoo.com

D. Ray
Department of Polymer Science and Technology
University College of Science and Technology
University of Calcutta
92 A.P. C Road
Kolkata 700009
India
E-mail: roy.dipa@gmail.com

A.K. Mohanty
Department of Plant Agriculture and School of Engineering
Crop Science Building
University of Guelph
Ontario N1G 2W1
Canada
E-mail: mohanty@uoguelph.ca

Dr M. Misra*
School of Engineering and Department of Plant Agriculture
Thornbrough Building
University of Guelph
Ontario N1G 2W1
Canada
E-mail: mmisra@uoguelph.ca

**Chapter 8**

Dr M.P. Staiger*
Biomaterials Research Group
Department of Mechanical Engineering
University of Canterbury
Christchurch
New Zealand
E-mail: mark.staiger@canterbury.ac.nz

Dr N. Tucker
The New Zealand Institute of Crop and Food Research
Lincoln
Christchurch
New Zealand
E-mail: TuckerN@crop.cri.nz

**Chapter 9**

Dr M. Duhovic, Dr S. Peterson and Dr K. Jayaraman*
Centre for Advanced Composites Materials
The University of Auckland
Building 740
Tamaki Campus
261 Morrin Road
Glen Innes
Auckland
New Zealand
E-mail: k.jayaraman@auckland.ac.nz

**Chapter 10**

J.E. Winandy*, R.S. Williams, A.W. Rudie and R.J. Ross
USDA Forest Service
Forest Products Laboratory
Madison, WI 53726-2398
USA
E-mail: jwinandy@fs.fed.us

**Chapter 11**

Professor E. Hansen
Department of Wood Science & Engineering
Oregon State University
USA
E-mail:
Eric.Hansen2@oregonstate.edu

**Chapter 12**

Dr P.J. Herrera-Franco* and Dr A. Valadez-González
Unidad de Materiales
Centro de Investigación Científica de Yucatán, A. C.
Calle 43 No. 130, Col. Chuburná, C. P. 97200
Mérida, Yucatán
México
E-mail: pherrera@cicy.mx

**Chapter 13**

Dr R. Joffe*
Division of Polymer Eng.
Luleå University of Technology
SE-971 87 Luleå
Sweden
E-mail: Roberts.Joffe@ltu.se

Dr J. Andersons
Institute of Polymer Mechanics
University of Latvia
Riga LV-1006
Latvia

**Chapter 14**

Dr S. Mishra*
Department of Earth Sciences
University of Ottawa
140 Louis Pasteur
Marion Hall
Ottawa
Canada K1N 6N5
E-mail: supriya.mishra@utoronto.ca

Professor M. Sain
Centre for Biocomposites and Biomaterials Processing
Faculty of Forestry
University of Toronto
33 Willcocks Street
Toronto
Canada M5S 3B3
E-mail: m.sain@utoronto.ca

**Chapter 15**

Dr J. Varna
Division of Polymer Engineering
Luleå University of Technology
SE-97187 Luleå
Sweden
E-mail: Janis.varna@ltu.se

# Introduction

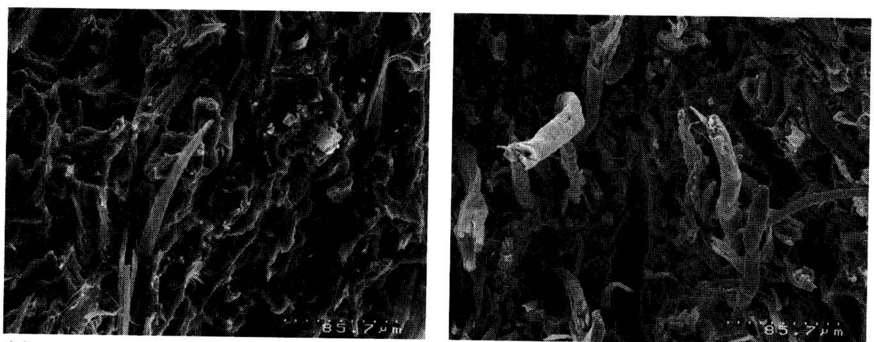
K L PICKERING, University of Waikato, New Zealand

Technological development coupled with consumer expectations continues to increase demands on the Earth's resources, leading to major issues relating to material availability and environmental sustainability. Recently, a general consensus with regard to the large contribution made by humans to the current phase of global warming has been reached. This will add further emphasis to the awareness of the need to act in an environmentally responsible manner, which has already become a major influence on government policy in many countries. This awareness has also led to increased interest in materials derived from more sustainable resources that can be processed with lower energy consumption requirements, as well as recyclable materials, including those from which energy can be recovered, as found within the spectrum of natural-fibre composites. Although the use of these materials is not new (their documented use dates as early as civilisation itself), these more recent incentives have encouraged the extension of their use.

One major area of development over the past decade has been in the use of compression moulded natural-fibre reinforced thermoplastic panels that have been widely adopted in the European automotive industry for parts such as door panels, headliners, package trays, dashboards and boot liners. This has been largely influenced by the European Union End-of-life Vehicle Directive, adopted in 2000, stating that from 2006, the reuse and recovery of an end-of-life vehicle should be a minimum of 85 wt% (with 80 wt% reused or recycled), increasing to 95 wt% (with 85 wt% reused or recycled).[1] Since 2000, steady growth of the use of natural fibres in European cars has been observed, increasing in Germany, for example, from around 10 000 tonnes in 2000 to 19 000 tonnes in 2005 (excluding processed cotton or wood fibre).[2]

Another more structurally demanding area of application has been in extruded 'plastic lumber' used for decking purposes mainly within the United States, although the large sectional thicknesses of this product mean that, again, the mechanical demands are not high. Indeed, much research effort has focused on improving the mechanical performance of natural fibre thermoplastic composites which could enable extension of their application. Much of that attention has been aimed at the improvement of interfacial strength, for which a range of fibre treatments and coupling agents have been assessed. The most successful in terms of mechanical benefits along with ease of use has been obtained with maleated propylene (MAPP) as a coupling agent, giving strength and stiffness improvement of greater than 100% compared with uncoupled composites.[3] Examination of fracture surfaces for natural-fibre polypropylene composites demonstrates the general dependence of mechanical properties on the failure mechanisms of natural-fibre composites and elucidates the dramatic improvement of properties in this particular instance; in the presence of coupling agent very little fibre pull-out can be observed, with fibre fracture coinciding with the major crack front (Fig. I.1(a)) in sharp contrast to composites without MAPP coupling agent (Fig. I.1(b)). Furthermore, this suggests that interfacial strength is no longer the limitation for improving mechanical performance. It seems likely that greater benefit and thus extension of use could be obtained elsewhere; for instance, by engineering fibre orientation, increasing fibre length and the use of different matrices, all of which are current areas of research. Alternative matrices such as thermosetting polymers or biodegradable polymers are also of interest where higher performance or biodegradability, respectively, is required.

Another major area that could extend the application of natural-fibre composites is the improvement of long-term performance including improved resistance to moisture, ultraviolet radiation and creep. As previously mentioned, the natural-fibre reinforced thermoplastic composites developed for the automotive industry as well as the more traditional wood reinforced thermoset matrices used commonly for office furniture are generally for interior parts. Although obviously decking is used in exterior applications, the low mechanical performance required disguises the durability issues that would occur with more demanding situations, particularly where higher fibre weight fractions would be required.



(a) (b)

*I.1* Demonstrating the influence of interfacial strength on fracture behaviour showing a 40 wt% hemp fibre reinforced polypropylene composite (a) with and (b) without coupling agent (courtesy of Gareth Beckermann, PhD student, Waikato University).

Overall, natural-fibre composites are seen as potential materials for many engineering applications. However, there are still important issues that limit their future use, including long-term performance and the ability to be able to predict performance during service. Fracture mechanics can give great insight into the physical effects occurring within these composites which enable the production of natural-fibre composites with improved properties.

This text has been arranged in a way to best demonstrate the issues of current importance to developments in the natural-fibre composite area. It comprises three main sections. The first section (Natural-fibre composites) gives an overview of the wide variety of materials and processing techniques used as well as the historical development of these materials. This section also includes the critical area of the interface or interphase that can be engineered to alter fracture mechanics and performance. In the second section (Case studies and opportunities), work is presented across the spectrum of application areas, including the automotive, structural and packaging industries as well as assessing opportunities for integration of biomass technologies. This section also includes market issues and the future potential for natural-fibre reinforced composites. The final section (Performance of natural-fibre composites) focuses on the behaviour of these materials, including methodologies for assessing behaviour and microstructural influences, relating to available models and current understanding of fracture mechanics over the short- and long-term time periods. For myself, this book has been a very exciting project and I am very grateful for the expert opinions from the contributing authors.

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