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Abstract

The 2nd International Conference on Sustainable Innovation emphasizes on natural resources technology and management to support the sustainability of mankind. The main theme of ICoSI 2014 "Technology and innovation challenges in natural resources and built environment management for humanity and sustainability " reflects the needs of immediate action from scientists with different fields and different geographical background to face the global issue on world's change.

Chapters (47)

Application of Organic Fertilizer and Plant Growth-Promoting Rhizobacteria (PGPR) to Increase Rice Yield and Quality

Chapter

Aug 2017 · ICoSI 2014 · pp.3-11

Oktavia S. Padmini · Sri Wuryani · Ruly Aryani

Generally, the application of high doses of chemical fertilizer continuously causes leveling production and decreasing rice quality. The objective of this research was to examine the effect of organic fertilizer and PGPR on rice yield…

View

Clustering of High-Yielding and Early-Maturing Soybean Genotypes

Chapter

Aug 2017 · ICoSI 2014 · pp.13-19

M. Muchlish Adie · Ayda Krisnawati

Global warming has potentially increased the intensity of drought and pest population. Soybean with early maturing (<80 days) tends to be more tolerant to those stresses through escape mechanism. The objective of this research wa…

View

Cyperus Rotundus L. Extracts as Botanical Fungicides to Control Soybean Rust Disease

Chapter

Aug 2017 · ICoSI 2014 · pp.21-27

Eriyanto Yusnawan · Alfi Inayati

Soybean rust disease caused by Phakopsora pachyrhizi Syd. is one of the most important diseases on soybean. Severe infection on soybean crops causes early defoliation. The yield loss caused by this disease has been reported up to 80…

View

Development of Breakfast Meals from Local Taro Using Extrusion for Food Security

Chapter

Aug 2017 · ICoSI 2014 · pp.29-39

Ermi Sukasih · Setyadjit

Extrusion technology is growing fast and been demanded by food processor. The selection of material for formulation (composite) is important to produce high quality and performance product. Taro, mung bean and banana are good…

View

Factors Determining the Practice of Sustainable Cassava Farming System in Tanjungsiang—West Java

Chapter Full-text available

Aug 2017 · ICoSI 2014 · pp.41-49

Carolina Carolina

For almost 6 decades, farmers in Tanjungsiang of West Java Province cultivate cassava (Manihot esculenta) as main crop without any sign of decrease in area nor productivity. Locally known as sampeu manggu or manggu cassava, the…

View

In Vitro Sterilization and Shoot Induction of Fig (Ficus carica L.) Using MS Containing GA3 Medium Supplemented with BAP and NAA

Chapter

Aug 2017 · ICoSI 2014 · pp.51-60

Innaka Ageng Rineksane · Rahman Budiawan · Gunawan Budiyanto

The purpose of this research was to obtain the proper sterilization method for fig (Ficus carica L.) shoot and determine the best combination of BAP and NAA for in vitro shoot induction of fig. The sterilization research was arranged in…

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Induction of Callus Cultures from the Leaves of Syzygium cumini (Linn.) Skeels in Woody Plant Medium with Variations of Growth Hormones

Chapter

Aug 2017 · ICoSI 2014 · pp.61-66

Tjie Kok Go · Xavier Daniel · Stevanus Soegiono

Syzygium cumini (Linn.) Skeels, known as jamblang, belongs to the family of guava (Myrtaceae). The plant can be found in India, Southeast Asia and Eastern Africa. This plant has a potential use for treatment of type 2 diabetes mellitus....

View

Nutritional and Physical Characteristic of Sweet Potato and Taro Flour Modified by Amylolytic Enzyme

Chapter

Aug 2017 · ICoSI 2014 · pp.67-72

Badrut Tamam

Nutrition improvement and security could be implemented by utilizing local commodities, such as sweet potato (Ipomoea batatas L) and taro (Colocasia esculenta (L) Schoot). An effort on food security using both commodities is by...

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Optimation of Breakfast Meals from Local Taro Using Response Surface Methodology

Chapter

Aug 2017 · ICoSI 2014 · pp.73-82

Setyadjit · Ermi Sukasih

The simplest method in producing plain breakfast meals from taro by preparing a dough, making the dough flat, making a flake, then drying the flake in a cabinet dryer. In this experiment optimation of cooking factors such as baking...

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Selection of Soybean Lines (Glycine max) Tolerant to Drought

Chapter

Aug 2017 · ICoSI 2014 · pp.83-92

Apri Sulistyo · Suhartina · Novita Nugrahaeni · Purwantoro S.P.

Soybean cropping pattern in Indonesia, which follows the pattern of rice-rice-soybean, causing soybean cultivation often encounter the problem of water deficiency due to soybean growing season which falls in the dry season....

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Synergism Between Sago Starch and Chitosan in Enhancing Biodegradable Film Properties

Chapter

Aug 2017 · ICoSI 2014 · pp.93-100

Indira Prabasari · Nafi Ananda Utama · Chandra Kurnia Setiawan

The research studied properties of biodegradable film from the mixture of sago starch and chitosan. The biodegradable film was obtained by solution casting method with addition of glycerol 1.5% as plasticizer. Mechanical properties of...

View

Variability of Soybean Genotypes Based on High Yield and Seed Size Supporting Industrial Raw Material

Chapter

Aug 2017 · ICoSI 2014 · pp.101-107

Ayda Krisnawati · M. Muchlish Adie

The main utilization of soybean with large seed size (>14 g/100 seeds) in Indonesia is for tempeh raw material. The aim of this research was to identify soybean genotypes based on high yield and seed size. Experiment was...

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Vegetables Mapping Using Production and Socioeconomic Indicators Approach

Chapter

Aug 2017 · ICoSI 2014 · pp.109-118

Weksi Budiaji · Juwarin Pancawati · Suherna

Founded in 2007, Serang was considered as one of the new cities in Indonesia. That was why vegetables commodities mapping was not available yet. This mapping was essential for a new city to create an accurate policy in order to...

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Willingness to Pay and Willingness to Work to Avoid Deforestation and Forest Degradation

Chapter

Aug 2017 · ICoSI 2014 · pp.119-129

Akhmad Solikin

Contingent valuation method (CVM) is widely applied to value environmental goods and services. Initially developed in developed countries, CVM now is also widely applied in developing countries. However, in many cases, value…

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A Cluster Model for Increasing Performance of Small and Medium-Scale Enterprises (A Case Study in Bogor, Indonesia)

Chapter

Aug 2017 · ICoSI 2014 · pp.133-137

Resista Vikaliana · Desi Harsanti · Dewi Sri Wulandari · Asti Andayani

Small Medium Enterprises (SME) is one of economic fundament in Indonesia. Their endurance has already known since Monetary Crisis in 1998. But, most of them have not managed well. Many problems occurs on them, such as…

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Clustering Residents Based on Perceptions Toward Tourism Growth in Yogyakarta, Indonesia

Chapter

Aug 2017 · ICoSI 2014 · pp.139-146

Harwati Harwati

The development of tourism sector in the region will deliver benefits for local community including the increase sales level, more job openings, the increase in the ability of people to learn foreign languages, encouragement to repair…

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Embedding Accountability Throughout the Innovation Process in the Green Economy: The Need for an Innovative Approach

Chapter

Aug 2017 · ICoSI 2014 · pp.147-158

Andri D. Setiawan · Rajbeer Singh · Henny A. Romijn

Innovation in the green economy entails transformative change in society. Vital infrastructure technologies in the fields of energy, water, communication, waste handling, and so on have many interdependencies with other economic sector…

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Tourist Village for Rural Economic Development

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Aug 2017 · ICoSI 2014 · pp.159-167

Agus Mansur · Riski Nobriandiro · Yasser Azka Ulil Albab

The majority of Indonesian people live in rural areas. Most of them are working in the agricultural sector. However, the agricultural sector is not going well so it cannot contribute to the welfare of the society. This factor pushes a massive…

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Innovative Women Entrepreneurs in the Green Economy: Two Case Studies from Mauritius

Chapter Full-text available

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S. Rosunee · Adeela Peer

Women make up 51% of the population of Mauritius, but only a very small percentage manages to emerge as entrepreneurs. Contextual inquiry was conducted with two women, both green entrepreneurs, to understand their…

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Optimization of Law Enforcement on Reclamation Process in Indonesia

Chapter

Aug 2017 · ICoSI 2014 · pp.179-188

Yordan Gunawan · Andika Putra · Mohammad Hazyar Arumbinang

Indonesia is blessed with abundant natural and energy resources. The natural and energy resources consist of mine, natural gas, and oil which spread out in all of regions of Indonesia. Nowadays, the development of mining activity is…

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Planning Livable Community with Social Systems Approaches: Medan, Indonesia

Chapter

Aug 2017 · ICoSI 2014 · pp.189-199

Dwira Nirfalini Aulia

Livable Community is an ideal condition desired by all people. The perfect

condition has variety specification based on the need of the community. Social system approaches the resident used as the approach of planning strategy of …

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Poverty, Its Measures and Determinants: Evidence Across Provinces in Indonesia

Chapter

Aug 2017 · ICoSI 2014 · pp.201-211

Masyhudi Muqorobin · Venia Prissi Ramadhani · Agus tri Basuki

This paper attempts to examine the measurement concepts and problems of poverty and provides empirical evidence, by analyzing the influence of population, gross domestic regional product, share of agriculture, share of…

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Quality Improvement of Product–Service Package of "Mangunan" Agrotourism Using Quality Function Deployment Approach

Chapter

Aug 2017 · ICoSI 2014 · pp.213-221

Nafis Khuriyati · Wahyu Supartono · Rahmat Hidayat

Mangunan is one of growing agrotourism in the district of Bantul Yogyakarta. Basically, Mangunan had many criteria to support the implementation of product–service package sustainability agrotourism that included product,…

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Spatial Use and Satisfactory Level of the High-Density Housing Residents

Chapter

Aug 2017 · ICoSI 2014 · pp.223-243

Sri Astuti Indriyati

This research presents evidence on how the space used by the residents and their satisfactory level towards space of living. The study proceeds by looking at what the occupants' perceptions towards their space. Various variables are us…

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The Development of DIY's Southern Coastal Communities: Issues and Challenges

Chapter

Aug 2017 · ICoSI 2014 · pp.245-253

Imamudin Yuliadi

The reality shows that Indonesia is one of the countries that have the longest beach in the world. This fact gives implication that the economic potential of people life at the beach is important factor to economic growth indoors welfare…

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The Effect of Leadership Style, Work Motivation, Organizational Culture and Job Discipline on Employees Performance

Chapter

Aug 2017 · ICoSI 2014 · pp.255-262

Retno Ulfayatun Hidayah · Ietje Nazaruddin

The purpose of this study is to analyze the influence of leadership styles, motivation, and organizational culture and work discipline on employee performance. This study is conducted to see whether there are differences in t…

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The Study of Snack Purchasing Behavior and Foreign Tourists' Eating Habits at Taiwanese Night Markets

Chapter

Aug 2017 · ICoSI 2014 · pp.263-270

Shu-Hsien Liao · pei-yuan Hsiao

Taiwan is well known for its reputation cuisine, and annually thousands of tourists come to Taiwan to taste authentic traditional cuisine, in addition to provide the residents' life needs, taking into account the meaning of leisure…

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The Sustainability of Bayt Al-Maal Wa At-Tamwil's Contribution to Yogyakarta Citizen

Chapter

Aug 2017 · ICoSI 2014 · pp.271-284

Masyhudi Muqorrobin · Yuli Utami · Abdiel Fadhil Ridho

This paper aimed at identifying the influence of selected BMT's products (Pr),

empathy of Islamic microfinance institution to the member (G), and profit-sharing ratio determination (Ps) on their member's welfare (Y). This welfare is the…

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Traffic Jam in Tuanku Tambusai Road, Pekanbaru City

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Lucky Prawira · Abdul Kudus Zaini · Puji Astuti

Traffic jam in urban road in big cities has been the main issue in developing countries such as Indonesia. It is so easy to own motor vehicles today. This is one of the causing factors of dense traffic. In Riau Province, particularly…

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Work in Progress—Using Transnational Education Program to Inculcate Social Innovation and Sustainability Mindset

Chapter

Aug 2017 · ICoSI 2014 · pp.299-306

Noel Kristian

With the rapid progress of globalization, there is a need to innovate the way educational institutions in developing students to be world ready to face current sustainability issues. Learning Express (LeX) program is Singapore Polytechni…

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2-D and 3-D Subsurface Liquefaction Potential Profiling Using Tomography Surface Waves Method

Chapter

Aug 2017 · ICoSI 2014 · pp.309-320

Sri Atmaja P. Rosyidi

A 6.3 Mw earthquake struck Yogyakarta region in 2006 causing many geotechnical damages, e.g., ground cracks, surface displacement, landslides and local liquefactions and soil billings occurred in some regions. From field…

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An Analysis of Biogas Productivity with Fixed Dome Type for Supporting Household-Base Energy in Nongkojajar, East Java-Indonesia

Chapter Full-text available

Aug 2017 · ICoSI 2014 · pp.321-330

Aminatus Sa'diyah · Katrin Klingenberg · Ridho Hantoro

Indonesia is a developing country endowed by various potential renewable energy resources. Among them is biogas which basically can be produced from the decomposition of biomass by the biochemical processes. Java is the most…

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Business-Oriented Technological System Analysis (BOTSA) at Eindhoven University of Technology: An Innovative Learning Method to Foster Entrepreneurship

Chapter

Aug 2017 · ICoSI 2014 · pp.331-336

Mara Wijnker · Han van Kasteren · Henny A. Romijn

BOTSA is an innovative teaching method for students with technical background in the field of sustainable energy technologies and an interest in entrepreneurship. Two core features of this method, namely the connection…

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Calcium Phosphate-Carbon Nanotube Composites for Load—Bearing Bone Implant Application

Chapter

Aug 2017 · ICoSI 2014 · pp.337-345

Gelar Gunawan · Iis Sopyan

The limited supply of bone graft is a major problem in human organ transplantation costing lives of many worldwide. Calcium phosphate (CaP) material has been considered the most favorable and best substitute in tissue…

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CFD Studies on the Flanged Diffuser Augmented Wind Turbine with Optimized Curvature Wall

Optimized Curvature Wall

Chapter

Aug 2017 · ICoSI 2014 · pp.347-355

M. Nurur Rochman · Aulia Nasution · Gunawan Nugroho

The Diffuser Augmented Wind Turbine (DAWT) offers potentials to cope with the wind availability situation like in Indonesia, i.e. with yearly average of 3–5 m/s. In this paper, computational CFD studies to get insight into the role of adding a…

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Developing Academic Executive Information System Uses Kimball Methodology: Case Study in an Indonesia Higher Education System

Chapter

Aug 2017 · ICoSI 2014 · pp.357-368

Asroni · Noor Akhmad Setiawan · Sri Suning Kusumawardani

Muhammadiyah University of Magelang (UMM) has integrated academic information systems in terms of both data and applications. This system has been constructed 6 years ago and has been used by the service level to the…

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Effect of Reservoir Sediment Flushing from Wlingi and Lodoyo Reservoirs on Downstream River Water Quality

Chapter

Aug 2017 · ICoSI 2014 · pp.369-378

Fahmi Hidayat · Surya Budi Lesmana · Ery Suhartanto

In order to cope with severe sedimentation problems in Wlingi and Lodoyo reservoirs in the Brantas River basin, East Java, Indonesia, sediment flushing has been conducted since August 1990, immediately after the eruption of Mt.…

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Entrepreneurship Creativity: An Implication for Architects' Competitiveness and Sustainability

Article Full-text available

Aug 2017 · pp.379-389

Mudashir Gafar · Rozilah Kasim · David Martin

The success of an entrepreneur and architect often linked directly or indirectly to the philosophy of creativity. The entrepreneurs greatly add to the success of firms and organisations as architects contributed to the built environment…

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Green Energy Approach for Batik Industry in Order to Increase Productivity and Maintain a Healthy Environment

Chapter

Aug 2017 · ICoSI 2014 · pp.391-400

Ramadoni Syahputra · Indah Soesanti

Batik is a piece of cloth applied by means of a dye-resist technique using "batik-wax" as the resisting medium. Indonesian batik was designated by UNESCO as a Masterpiece of Oral and Intangible Heritage of Humanity. As part of the…

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Optimization Potential Value Added of Sunda Strait Bridge Construction in Accessibility Function Model

Chapter

Aug 2017 · ICoSI 2014 · pp.401-410

Wiratman Wangsadinata · DM Ma'soem · Delvia Lestari

In the implementation of Sunda Strait Bridge (SSB) development as a public transportation facility, there is a consistent purpose with the acceleration vision and the expansion of Indonesian Economic Development that is "Creating an…

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Rainwater Harvesting System Implementation for Domestic Water Use: The Environment and Financial Benefits

Chapter Full-text available

Aug 2017 · ICoSI 2014 · pp.411-421

Imroatul Chalimah Juliana · Muhammad Svahril Badri Kusuma ·

Muhammad Cahyono · [...] · Widjaja Martokusumo

Rainwater harvesting (RWH) system is a technology that focuses on sustainability and supports the sustainable environment development. The implementation of RWH systems provides many environment and financial...

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The (In-)Visible Hand: A Governance Perspective on Low-Carbon Transitions in the PRC

Chapter

Aug 2017 · ICoSI 2014 · pp.423-433

Linda Katrin Westman

The multi-level perspective on sociotechnical transitions (MLP) is a framework that has been widely applied in analysing the dynamics of innovation and change in large technical systems. The model has proved useful for explainin...

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The Effective Mixture of Anatase–Rutile Nanoparticles as Dye-Sensitized Solar Cell (DSSC) Using Natural Dye of Garcinia mangostana and Rhoeo spathacea Extract

Chapter

Aug 2017 · ICoSI 2014 · pp.435-441

Bibit Lestari · Irana eka Putri · Ruri Agung Wahyuono · [...] · Doty Risanti

A synergistic effect between anatase and rutile TiO2 is known to be able to improve light harvesting and the overall solar conversion efficiency. Dye-sensitized solar cell (DSSC) was fabricated using the mixture of anatase–rutil...

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The Prospective Analysis of Coastal Town Development Based on Waterfront City (Case Study: Bantan Sub-District, Bengkalis–Riau Province)

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Aug 2017 · ICoSI 2014 · pp.443-454

Puji Astuti · Mardianto Manan · Febby Asteriani · [...] · Dharfrimadil Akhyar

Bantan Sub-district is one of area in Bengkalis District, Riau Province. Located on the coast called the Selat Baru Beach, ecological island separated from its parent, in this case is the Island of Sumatra, remote and insular nature. Havin...

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User Interface Evaluation of Indonesian Online News Portals: Case Study of Vivanews and Detikcom

Chapter

Aug 2017 · ICoSI 2014 · pp.455-472

Muhammad Yazid · Rizky Arya · Slamet Riyadi

Following the advance of information technology, nowadays online news portal is very popular. By accessing news portal, people can easily read news from their smartphone, smart tab, and other mobile devices. In terms of human–...

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Waste Prevention Effectiveness of Batik Production in Yogyakarta, Indonesia

Chapter

Aug 2017 · ICoSI 2014 · pp.473-481

Mohammad Rianda Al Rasyid · Retno Widowati Pa

As a form of art rooted deep in Indonesian culture, Batik has evolved to its modern form and become internationally recognized. Their production consequently has experienced an increase as global demand continues. Such...

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Watershed Erosion Analysis (Case Study of Citarum Upstream Watershed)

Chapter

Aug 2017 · ICoSI 2014 · pp.483-497

Ana Nurganah Chaidar · Indratmo Soekarno · Agung Wiyono · Joko Nugroho

This paper presents the results of the study in partial yearly erosion rate changes, and a simulation of land use according to the pattern space. Watershed ecosystem changes are represented by the modification of land...

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Jan 1999 · 469-474

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Some lessons from Yogyakarta earthquake of

Jan 2006 · 1-8

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Fast Surface Wave and Free Mode Computations

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Dec 1972

Fred Schwab · L. Knopoff

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'Simplified procedure for evaluating soil liquefaction potential'

Article

Sep 1971

B. Seed · I. M. Idriss

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Multichannel Analysis of Surface Wave (MASW) Method for Geotechnical Site Characterization

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Use of nuclear power in Germany 1997

December 1998 · Kernkraftwerke in Deutschland: Betriebsergebnisse ..

F Philippcyk · J Hutter

The German Federal Office for Radiological Protection (BfS) presented a survey of the use of nuclear power in Germany as of December 31, 1997. The report contains the main data of all nuclear generating units, nuclear fuel cycle plants, and stores of radioactive waste. The operating record is supplemented by information about the state of use of Mox fuel elements. The status of decommissioned ... [Show full abstract]

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The manufacturing of zirconium metal powder by means of a high temperature plasma process

June 2010 · IEEE International Conference on Plasma Science

J.L. Havenga · J. T. Nel

Summary form only given. The most general application for high purity zirconium metal alloys is for cladding material for nuclear fuel assemblies in nuclear power plants. A process was developed to manufacture zirconium metal powder from ZrCl4 or ZrF4 with a high temperature DC non - transfer arc plasma. Mg or Ca metal was used as reductant. The reactants were feed directly into the high ... [Show full abstract]

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Electric Heaters for Thermophysical Models of Fuel Elements

December 2000 · Atomic Energy

V.N. Smolin · V. P. Shishov · A. I. Emel'yanov · [...] · S.M. Balashov

Tubular electric heaters are widely used for scientific investigations in reactor thermophysics and for equipment in a nuclear power plant. Electric heaters equipped with thermocouples and possessing properties close to those of a fuel element - casing temperature, power, heat flux distribution, and so on - are often used to simulate a fuel element. In contrast to direct-heating tubes, the ... [Show full abstract]

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Social and political issues in siting a nuclear-fuel waste disposal facility in Ontario, Canada

March 1998 · Canadian Geographer / Le Géographe canadien

Richard G. Kuhn

An environmental assessment of the Canadian Nuclear Fuel Waste Disposal Concept was initiated in 1989. The primary purpose of the assessment is to determine the technical feasibility of burying nuclear-fuel waste deep into the Canadian Shield. If deemed acceptable, a second phase of facility siting will commence. The purpose of this paper is to evaluate the social and political dimensions of ... [Show full abstract]

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Variable temperature micropillar compression to reveal basal slip properties of Zircaloy-4

March 2019 · Scripta Materialia

Siyang Wang · Finn Giuliani · T. Ben Britton

Zircaloy-4 is widely used as nuclear fuel cladding materials, where it is important to understand the mechanical properties between room temperature and reactor operating temperatures (around 623 K). To aid in this understanding, we have performed compression tests on micropillars aligned to activate basal slip across this temperature range. Engineering analysis of the results indicates that the ... [Show full abstract]

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Severe accident management

December 2010

A. K. Saxena · S. P. Limaye · P. K. Bhaumik

Complex thermal-hydraulic and severe accident phenomenon is selected during Severe Accident Management. Deterministic approach is considered while assessing the consequences by severe accident due to Loss of Coolant Accident (LOCA) in vertical nuclear fuel channel. Mitigatory or Severe Accident Management has been used to arrest the temperature of clad such that it remains fairly below its ... [Show full abstract]

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Aerospace nuclear safety at APL: 1997-2006

January 2007 · Johns Hopkins Apl Technical Digest

Yale Chang

NASA's Galileo, Cassini, Mars Exploration Rovers Spirit and Opportunity and New Horizons spacecraft have returned spectacular planetary scientific findings, including tantalizing evidence of conditions that might support life on Europa, Mars, and Enceladus. These missions were all enabled by space nuclear power. Preparation for NASA missions carrying nuclear material must consider the ... [Show full abstract]

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Neutronic analysis for potential Accident Tolerant Fuel UO2-BeO in the light water reactor

December 2018 · Annals of Nuclear Energy

Qian Zhang · Xiang Wang · Yunfei Zhang · [...] · Chao Wang

The enhanced thermal conductivity oxide (ECO) nuclear fuel with BeO is analyzed from the aspect of neutronics. The Westinghouse 17x17 pressurized water reactor lattice model is selected as the reference and the influence on the neutronic features of different volume fractions of BeO is investigated by Monte Carlo depletion code Serpent. Results from criticality calculation of fresh fuel and ... [Show full abstract]

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Facility design philosophy: Tank Waste Remediation System Process support and infrastructure definit...

November 1995

C.E. Leach · J.D. Galbraith · P.R. Grant · [...] · P.J. Schroeder

This report documents the current facility design philosophy for the Tank Waste Remediation System (TWRS) process support and infrastructure definition. The Tank Waste Remediation System Facility Configuration Study (FCS) initially documented the identification and definition of support functions and infrastructure essential to the TWRS processing mission. Since the issuance of the FCS, the ... [Show full abstract]

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R. L. Feuerbacher · P. G. Fields · R. Killgore · C. H. Wu

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On the Possibility of Underwater Storage of Defueled Nuclear Submarine Reactor Compartments

January 1999

B. G. Pologuikh · YU. V. Sivintsev · N. S. Khlopkin

In Russia the process of the decommissioning of nuclear submarines (NS) is accompanied by accumulation of stored afloat hermetically sealed packing with reactor compartments without spent nuclear fuel (SNF). The packing are subject to temporary storage up to a moment of their consequent decomposition or transportation to the future special storage site on the shore.

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Synergism Between Sago Starch and Chitosan in Enhancing Biodegradable Film Properties

Indira Prabasari, Nafi Ananda Utama and Chandra Kurnia Setiawan

Abstract The research studied properties of biodegradable film from the mixture of sago starch and chitosan. The biodegradable film was obtained by solution casting method with addition of glycerol 1.5% as plasticizer. Mechanical properties of biodegradable film from sago starch and chitosan were determined including tensile strength, elongation, color and biodegradability. To study shape surface morphology of biodegradable film, the microfracture of biodegradable film was observed by scanning electron microscopy (SEM). Biodegradable film with the composition of sago starch and chitosan 1:1 significantly had the lowest number of tensile strength. The study revealed that addition of chitosan improved biopolymer elongation and brightness, but it weakened tensile strength of biopolymer and reduced its biodegradability.

Keywords Sago starch · Chitosan · Biodegradable film · SEM

1 Introduction

Biodegradable film from the mixture of polysaccharides and proteins has been studied intensively as a substitute for synthetic polymer. Researchers have their own definitions of biodegradable film/biodegradable plastic. Biodegradable film is a plastic material that its chemical structure is change under certin condition therefore affects its properties. The chemical structure changes can occur from the attack of microorganisms such as fungi, bacteria and algae. Another definition of the biodegradable plastic is a polymer in which the molecular weight is being lower because of the degradation wherein at least one step in the degradation process occurs through the natural metabolism of the organism.

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One of the important properties of biodegradable film is its biodegradability that is an ability of materials to be degraded. The term of biodegradation sometimes confused with the term of deterioration. Deterioration can be defined as a loss in physical integrity of a material, whereas biodegradation is a biochemical transformation of compounds by microorganisms and results in mineralization or incorporation into microbial biomass. Biodegradation process produces CO_2 and H_2O under aerobic conditions or CH_4 and CO_2 under anaerobic conditions. From the definition, a distinction can be drawn that the deterioration will be fragmented plastic, but the plastic particles will still remain in the environment, while biodegradation will decompose the plastic particles through the process of mineralization.

Starch including from mung bean, potato, sweet potato and its derivatives has been widely studied in the manufacture of biodegradable films and capsules. Starch is used as a substitute for gelatin in the manufacture of these biodegradable films for its simplicity to be molded into films and its properties as high oxygen barrier, and it has a good mechanical strength [1]. Among other starches, sago starch has some advantages as the base material of biodegradable films because it has low temperature on gelatinization, low degree on sineresis, high degree on viscosity and it is easy to be attacked by mold. Another advantage is that sago starch has fairly high amylose content approx. 27% which is suitable for making a biodegradable film with solid gel [2].

Basically, polysaccharide-based biodegradable films have brittle properties and their mechanical properties are unfavorable. Therefore, in the manufacture of biodegradable film gelling agent, e.g., chitosan, and plasticizer, e.g., glycerol, sorbitol and polyethylene glycol are added to overcome fragility and to improve elasticity [3]. Chitosan is a natural cationic polysaccharide obtained from deacetylation of chitin which is widely available in nature. According to the chemical structure, chitosan consists of monomer 2-amino-2-deoxy-D-glucose (glucosamine) which shows the properties of biomedical polymers such as non-toxic, biocompatible and biodegradable. Chitosan structure is similar to cellulose, and its ability to form a gel in the acid is due to its properties to build a matrix in the polymer system. In the manufacture of biodegradable films, the addition of chitosan and the presence of polyacrylic acid (PAA) produce $CaCO_3$ crystals that will affect the morphology of film. There was areport that the addition of chitosan to maize starch biodegradable film produces a film with more strength.

The aim of the study was to produce biodegradable film which has similar properties with synthetic plastic. The synergism between sago starch and chitosan was then studied including the character of biodegradable film produced, the effect of sago starch and glycerol concentration on the physical and mechanical properties, i.e., tensile strength and elongation, and the rate of biodegradable film degradation.

2 Research Method

2.1 Sample Preparation

Biodegradable film was prepared from sago starch and mixture between sago starch and chitosan as follows: (1) sago starch without chitosan (BS); (2) sago starch blended with chitosan and the ratio was 1:1 (BKS I); and (3) sago starch blended with chitosan and the ratio was 2:1 (BKS II). The film was prepared by mixing polysaccharides with glycerol and distilled water at 50 °C. The solution was stirred using an agitator at 100 rpm for 30 min. A commercial sago starch and chitosan were then added to the glycerol solution, while it was stirred and distilled water was added until the solution reached 200 mL. The stirring process was continued until it became a clear solution. The solution then poured onto five pieces of 20 cm × 30 cm acrylic glass plate and stood for 15 min. After the frame was released, biodegradable films on acrylic glass plate were then dried in oven at 50 °C. After drying, the film was released from acrylic glass plate and wrapped by aluminum foil.

2.2 Tensile Strength and Elongation Measurement

Biodegradable film was cut and linked horizontally on Instron Universal Testing Machine tools (Zwick Z.05 texture analyzer) connected to a computer for data analysis.

2.3 Brightness Test

Measurement of brightness used a color index Chroma Meter Minolta CR-600 with the attribute "L" indicating the level of brightness, "$+a$" degree of redness, "$-a$" degree of greenness, "$+b$" yellowish level and "$-b$" the bluish level.

2.4 Biodegradability Test

Biodegradability test was conducted using soil burial test of Behjat et al. [4] with slight modifications. Testing was done by cutting the film with the size of 5 × 10 cm. It was then buried approx. 20 cm below the ground for one week. The film was observed and the film remained was measured.

2.5 Scanning Electron Microscopy (SEM)

Observations using electron microscopy were conducted to determine the microstructure of biodegradable films.

3 Results and Discussion

3.1 Film Properties

Physical characteristic of biodegradable film was shown in tensile strength and elongation (Table 1). Chitosan affected characteristics of biodegradable film. The cross-link between sago starch and chitosan (BKS I and BKS II) lowered tensile strength of film produced due to decrease in starch concentration. The decrease in starch concentration was in line with the decrease in amylose content in biodegradable film. The result was similar to the previous research that mung bean starch with the highest amylose content (30%) had the highest tensile strength [1]. The increase in amylose content also increased aggregation from the formation of hydrogen bonds between polymers that formed amylose microcrystal that resulted in film with high tensile strength [5].

The result showed that BKS I film had a higher tensile strength than BKS II film. Studies showed that increase in the ratio of starch and chitosan composite decreased tensile strength of the film. The decrease in tensile strength that was in line with the increase in starch ratio was caused by the formation of intramolecular hydrogen bonds' starch that was larger than the intermolecular bonding, resulted in separation phase between the two main components [6].

Starch contains macromolecules, such as amylose and amylopectin, which form a solution when heated with water and become a gel after cooling. During the process of forming a gel, inter- and intramolecular cross-linking is established to form microcrystalline regions [7]. Starch components without plasticizer resulted in increase in crystallinity that occurred during the formation of the film which increased tensile strength. This was more obvious in more rigid starch films [8]. It also occurred in elevated concentrations of chitosan that result in decreased crystallinity of the films [6].

Table 1 Mechanical properties of sago starch–chitosan biodegradable film

Sago starch–chitosan concentration	Tensile strength (MPa)	Elongation (%)
BKS I	29,277[b]	493,239[a]
BKS II	24,502[b]	447,872[a]
BS	69,004[a]	318,846[a]

Description The value is the mean of three replicates of analysis ± standard deviation; same superscript letters indicate no significant difference ($P > 0.05$)

For elongation, BSI film had the highest elongation values though not significantly different from other treatment. It showed that the addition of chitosan can increase the percentage elongation value of the film. Elongation value was inversely proportional to the film tensile strength values. Previous study showed that the combination of starch–chitosan film had significantly higher elongation value than the film made from starch or chitosan itself [9]. Higher amylose content in the film will result in a stronger starch intermolecular force, therefore the film with less flexibility and stronger in tensile strength has lower number in elongation [6].

3.2 *Film Brightness*

Table 2 shows that addition of chitosan affected starch color. L value stated brightness parameters with the range value 0–100 (black to white), while the b value stated chromatic color mixture of blue–yellow with +b values of 0–70 for yellow and 0 to −70 for blue.

Increasing the *L* value indicated the level of brightness of the starch. The results of the study showed that the reduced levels of sago improved the brightness of biodegradable films. In *b* value, decreasing the levels of sago in biodegradable films was in line with the decrease in b value. Previous study from Chillo et al. [10] indicated the same phenomenon where the L and b values increased with increasing chitosan concentrations.

3.3 *Biodegradability Test*

Biodegradation is the result of an enzymatic process and involves both microorganism and macroorganism. Microorganism accelerates degradation by enzymes and may occur in aerobic or anaerobic conditions. Linear polymer is generally more easily degraded than the branched polymers [11]. Table 3 shows the result of film biodegradation.

Sago starch–chitosan film (BKS I and BKS II) had lower degradation compared to sago–starch film (BS). It indicated that addition of chitosan inhibited the

Table 2 Effect of chitosan on degree of white sago starch films

No	Film	Color		
		L	*A*	*B*
1	BKS I	31.49^{b}	-0.67^{a}	3.85^{c}
2	BKS II	25.47^{a}	-0.39^{a}	2.21^{b}
3	BS	25.98^{a}	-0.73^{a}	1.86^{a}

Description The value was the mean of three replicates of analysis ± standard deviation; same superscript letters indicate no significant difference ($P > 0.05$)

Table 3 Biodegradation of sago starch–chitosan film

Sago starch–chitosan concentration	Soil burial test (cm^2/week)
BKS I	62
BKS II	24
BS	104

degradation by microbes because chitosan was antimicrobial and antifungal, the same phenomenon which was found in Fernandez-Saiz et al. [12] and Ziani et al. [13]. In other work, hydrogen bond interactions between tapioca starch and chitosan reduced the availability of hydrophilic groups, diminishing their interactions with water molecules. It was also observed that when chitosan coating was applied to salmon fillet pieces, the antimicrobial effectiveness was greater than when chitosan–tapioca starch blends were applied [14]. However, observations of the rate of degradation showed that degradation of BKS II film was smaller than BKS I. It might be due to the presence of other organisms in the treatment media that were accelerating the degradation process.

3.4 Microstructure Observation Using SEM

Observations using electron microscopy were conducted to determine microstructure of the film. The SEM analysis was only conducted for BKS I that had better mechanical properties compared to BKS II and BS. The results of SEM analysis of BKS I are presented in Fig. 1.

Figure 1 shows the outer structure of BKS I that was compact, continuous, prevalent and not porous. The result was similar to the chitosan film SEM from Valenzuela et al. [15] and sago starch film Afiq and Azura [16]. The structure was not homogeneous that might be caused by the imperfection of intramolecular bond between chitosan and sago starch. The imperfection was due to the starch melting point that did not reach maximum temperature. It prevented starch granule from fully shedding so that it became soluble and lost its intermolecular bond [14].

4 Conclusion

The study shows that chitosan improved mechanical properties of sago starch film in elongation value and also improved film brightness. However, addition of chitosan decreased tensile strength value and degradation rate. The investigation of permeability characteristics and mechanical properties with addition other resources was needed to obtain comprehensive knowledge of biodegradable film.

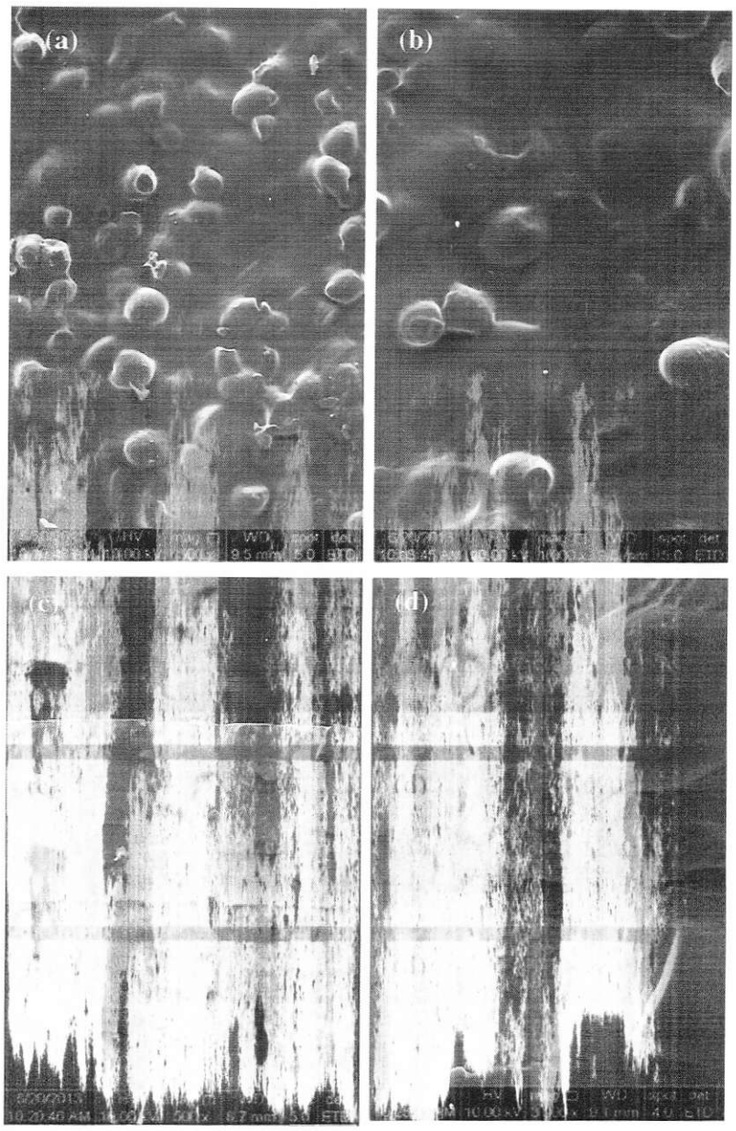

Fig. 1 Scanning electron microscopy observations of BKS I with various magnifications after soil burial test for 1 week. Biodegradable film looks over 500× magnification (**a**) and 1000× (**b**), 500× magnification side view (**c**) and 3000× (**d**)

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