Makalah

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**Abstracts Of Selected Articles**

## ECONOMICS



## HEVEA



## LATEX CHEMISTRY & TECHNOLOGY



## RUBBER CHEMISTRY & TECHNOLOGY



## TYRES

**OTHERS**



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*UPP April 2019*

## ECONOMICS

### *RUBBER COOPERATIVES--THAILAND*

Dejchanchaiwong, R.; Kumar, A.; Tekasakul, P.
Performance and economic analysis of natural convection based rubber smoking room for rubber cooperatives in Thailand
**Renewable Energy (2019) 132:233-242**

A modified rubber sheet smoking room was designed, constructed and tested, with uniform hot air flow inside in it, so that the temperature difference between any plane was less than 7 °C. This room can dry up to 1500 sheets in 72 h. Specific fuel wood consumption was 0.42 kg/kg of dried rubber. It consumed 67% less fuel wood and increased the fraction of good quality rubber sheets by 8.5% when compared to a conventional rubber smoking room. Thermal efficiency also increased from 6.9% to 15.7%. Moreover, the modified smoking room can save 1414 USD/year with payback period of 5.7 years. Therefore, the modified design can be recommended to rubber cooperatives for a better return.

### *RUBBER INDUSTRY AND TRADE -- OUTLOOK*

Kawano, M.
Changing resource-based manufacturing industry: the case of the rubber industry in Malaysia and Thailand
**In: Tsunekawa, K.; Todo, Y. (eds) Emerging states at crossroads. Singapore: Springer, 2019: pp.145-16**

This chapter explores the development potential of the rubber industry in Malaysia and Thailand, which have been leaders in the production of natural rubber (NR) since the 20th century. The analysis of NR producing (upstream segment), processing (midstream segment) and rubber-based manufacturing (downstream segment) in Malaysia and Thailand will find the different timing and sectoral composition in the development of the rubber sector of two countries. It will become clear that in spite of such differences, the two countries share a development pattern in one important respect: The public sector played a crucial role in the development of the upstream segment, while the successful development of the downstream segment largely depends on innovative

activities of private entrepreneurs to explore niche international markets for specialized rubber products.

## HEVEA

### *GENETIC VARIATION ANALYSIS*

Antwi-Wiredu, A. et al.
The use of microsatellite markers in genetic variation analysis of some introduced rubber tree (*Hevea brasiliensis)* clones cultivated in Ghana
**Journal of Agricultural Sciences – Sri Lanka (2019) 14(1): 8-16**

Genetic makers are indispensable in the genetic quantifi cation and characterization of plant species of which rubber tree is no exception. Markers have been used severally in genetic identifi cation and diversity analysis of rubber tree species. However, in Ghana genetic diversity and relatedness among introduced rubber tree species are limited. The study is aimed to use microsatellite markers to assess the genetic variability and evaluate genetic relationships among clones of Hevea brasiliensis cultivated in Ghana.

Roy, C.B. et al.
Transcriptome profiling reveals genetic basis of disease resistance against *Corynespora cassiicola* in rubber tree (*Hevea brasiliensis)*
**Current Plant Biology (2019):** *https://doi.org/10.1016/j.cpb.2019.02.002*

Corynespora leaf disease caused by *Corynespora cassiicola* (Berk. & Curt.) is one of the major diseases responsible for significant yield loss in rubber trees (*Hevea brasiliensis*). Next-generation sequencing based transcriptomic study of two rubberclones: RRII 105 (susceptible) and GT 1 (moderately resistant) were performed to understand the molecular basis of host tolerance to fungal diseases. Genes encoding disease resistance proteins, leucine-rich repeat proteins and genes involved in carbohydrate metabolic processes were significantly up-regulated in GT 1 upon infection, but were either completely suppressed or down-regulated in RRII 105. Transcription factor activity was a major molecular function triggered in both inoculated clones. Gene Ontology analysis revealed that majority of the transcripts was enriched for defense response, response to

stimulus and stress. Higher expression of 118 transcripts with complete ORFs was identified in inoculated GT 1, indicating their possible role in disease resistance. In addition, both unique and common simple sequence repeats (SSRs) were identified. *In silico* analysis revealed 191 informative SSRs differentiating the two clones. Variant calling in control and disease GT 1 transcriptomes with reference to RRII 105 revealed over one lakh putative base substitutions. Microarray was used to validate the results obtained on transcriptional responses. Biotic stress overview from MapMan analysis revealed stronger activation of defense-related genes, receptor-like kinases and transcription factors. This study presents the first comprehensive transcriptome of resistant and susceptible rubber clones in response to *C. cassiicola*. The newly identified differentially regulated genes and sequence variation provide critical knowledge for understanding the genetic basis of disease resistance and marker development.

***LATICIFER CELL***

Shi, M. et al.
The formation and accumulation of protein-networks by physical interactions in the rapid occlusion of laticifer cells in rubber tree undergoing successive mechanical wounding.
**BMC Plant Biology (2019) 19(1):1:** *https://doi.org/10.1186/s12870-018-1617-6*

Although the wound response of plants has been extensively studied, little is known of the rapid occlusion of wounded cell itself. The laticifer in rubber tree is a specific type of tissue for natural rubber biosynthesis and storage. In natural rubber production, tapping is used to harvest the latex which flows out from the severed laticifer in the bark. Therefore, study of the rapid wound-occlusion of severed laticifer cells is important for understanding the rubber tree being protected from the continuously mechanical wounding. Using cytological and biochemical techniques, we revealed a biochemical mechanism for the rapid occlusion of severed laticifer cells. A protein-network appeared rapidly after tapping and accumulated gradually along with the latex loss at the severed site of laticifer cells. Triple immunofluorescence histochemical localization showed that the primary components of the protein-network were chitinase, β-1,3-glucanase and hevein together with pro-hevein (ProH) and its carboxyl-terminal part. Molecular sieve chromatography showed that the physical interactions among these proteins occurred under the condition of neutral pH. The interaction of β-1,3-glucanase respectively with hevein, chitinase and ProH was testified by

surface plasmon resonance (SPR). The interaction between actin and β-1,3-glucanase out of the protein inclusions of lutoids was revealed by pull-down. This interaction was pharmacologically verified by cytochalasin B–caused significant prolongation of the duration of latex flow in the field.

Tan, D. et al.
Comparative morphology of in vivo and in vitro laticiferous cells and potential use on in vitro laticifiers in early selection of rubber tree clones
**Trees (2019) 33(1): 193-203;** *https://doi.org/10.1007/s00468-018-1768-y*

The rubber tree (*Hevea brasiliensis* Muell. Arg.) is a perennial crop with a breeding cycle of approximately 30 years in the conventional breeding practices. The lack of suitable parameters linking the juvenile and adult trees has made the early selection attempts inefficient. The laticifer density in callus of young tissue is positively correlated with the rubber yields of adult trees and can serve as an early selection marker to accelerate rubber tree breeding. Results indicate that the secondary laticifers have smooth lateral walls and perforated end walls and belong to articulated anastomosing laticifers. The primary laticifers are unbranched, non-articulated, and anastomosing, and have bumpy lateral walls when matured. The callus-derived laticifers are morphologically similar to the secondary laticifers with smooth lateral walls and the existence of end walls, and similar relative cell wall thickness.

***LEAF DISEASES***

Cao, X. et al.
Three *Colletotrichum* species, including a new species, are associated to leaf anthracnose of rubber tree in Hainan, China.
**Plant Disease (2019) 103(1):117-124**

*Colletotrichum gloeosporioides* and *C. acutatum* have been reported to be causal agents of anthracnose disease of rubber tree. Recent investigations have shown that both *C. gloeosporioides*and *C. acutatum* are species complexes. The identities of *Colletotrichum* species causing anthracnose disease of rubber tree in Hainan, China, are unknown. In this study, 106 isolates obtained from rubber tree with symptoms of anthracnose were collected from 12 counties of Hainan and identified at the species complex level based on the ITS sequences and colony morphologies. Seventy-four isolates were identified as *C. gloeosporioides* species complex and the other 32 isolates as *C. acutatum* species complex. Forty-two

isolates were selected for further multilocus phylogenetic analyses in order to identify the isolates to the species level. Twenty-six isolates from the *C. gloeosporioides* species complex were characterized for partial sequences of seven gene regions (*ACT*, *TUB2*, *CHS-1*, *GAPDH*, ITS, ApMat, and GS), and the other 16 isolates from the *C. acutatum* species complex for five gene regions (*ACT*, *TUB2*, *CHS-1*, *GAPDH*, and ITS). Three species were identified: *C. siamense* and *C. fructicola* from the *C. gloeosporioides* species complex, and a new species *C. wanningense* from the *C. acutatum* species complex. Artificial inoculation of rubber tree leaves confirmed the pathogenicity of the three species. The present study improves the understanding of species causing anthracnose on rubber tree and provides useful information for the effective control of the disease.

Carvalho, D.D.C. et al.
Molecular, morphophysiological and pathogenic characterization of eucalypt *Pestalotiopsis grandisurophylla* isolates, a new species
**Trop. Plant Pathol. (2019);** *https://doi.org/10.1007/s40858-019-00277-0*

Species of *Pestalotiopsis* have been reported to be pathogenic to eucalypt, yet few studies have addressed their real pathogenic potential or even their diagnosis. The objective of this study was to carry out the molecular, micromorphological, physiological and pathogenic characterization of four isolates of *Pestalotiopsis* sp. found in eucalypt leaf spots. DNA from the isolates was extracted and PCR amplified using primers for the internal transcribed spacer (ITS), partial β-tubulin (TUB) and translation elongation factor 1-alpha (EF1-α) gene regions. For morphophysiological characterization, the fungal structures were measured and isolates evaluated for mycelial growth and sporulation under different light regimes (0, 12, and 24 h). Pathogenicity tests were conducted on healthy eucalypt leaves. The results revealed that (a) the amplified ITS region is too conserved to be used for identification of *Pestalotiopsis* species, and thus, TUB and EF1-α sequences are recommended for this purpose; (b) based on micromorphological characteristics and DNA sequences, the four isolates were identified as the new species *Pestalotiopsis grandis-urophylla*; (c) *P. grandis-urophylla* presents faster mycelial growth when cultivated in the dark, but for mass production of inoculum the light regime does not have a strong influence; and (d) the pathogenic potential varied among the *P. grandis-urophylla* isolates.

Wu, R.H.; Zhang, Y.; Li, Z.P.
First report of leaf spot on rubber tree caused by *Lasiodiplodia pseudotheobromae* in China.
**Plant Disease (2019) 103(1):117-124:** *https://doi.org/10.1094/PDIS-08-18-1431-PDN*

Rubber tree (*Hevea brasiliensis Muell. Arg.*) is an important economic crop in the tropical regions of China, which used to produce natural latex and is mainly grown in Hainan, Guangdong, and Yunnan Provinces. In August 2017, leaf spots were observed on nearly 33% of the rubber trees (n = 200, clone RRIM600) in a plantation of Sanya (Hainan Province), and the crown disease severity rating was 5 (scale 1, 3, 5, 7, 9). The disease occurred in hot weather, with temperatures ranging from 26 to 35°C. The disease mainly endangers the adult leaves of rubber trees. Symptomatic leaves initially exhibited small, dark brown, round or oval spots with an obvious yellow halo, subsequently expanding into round, semicircular, or irregularly shaped gray-white lesion with scattered black spots. There was a distinct dark brown necrotic zone at the junction of the diseased and healthy tissue, surrounded by a yellow halo. Lesion expansion was not limited by the lobular veins, but the main vein. Finally, the leaves with extensive lesions gradually dried and dropped off of the plant. The diseased tissues were excised from 10 infected leaves with typical symptoms, which were taken from several individual rubber trees and surface sterilized by soaking in 70% ethanol for 10 s followed by 1 min in 0.1% $HgCl_2$, rinsed three times with sterile water, and then transferred to potato dextrose agar (PDA) and incubated at 28°C.

Yusoff, N.M et al.
Real-time *Hevea* leaves diseases identification using sobel edge algorithm on FPGA: a preliminary study
***Paper presented at 9th IEEE Control and System Graduate Research Colloquium, held at Grand Blue Wave Hotel, Shah Alam, Selangor from 3-4th August 2018.***
**(Published online in IEEE 1st March 2019)**

Real-time image processing is related with typical frame rate that required processing all the frames as soon as the image is captured. Fast processing time is required for edge detection since it is needed to be carry out in a real time. This paper proposes a real-time edge detection technique for identifying Hevea leaves diseases (rubber tree leaves) in images and its hardware implementation. Three major Hevea leaves diseases which are *Corynespora* Leaf Spot, Bird's

Eye Leaf Spot and Collectotrichum Leaf Disease used in this study for image comparison. The disease on the leaves can be detected through edge detection by using Sobel edge detection algorithm. The realtime edge detection result generated by FPGA Cyclone IV E which is displayed through a monitor is compared to Sobel edge detection algorithm that is generated with MATLAB. The algorithm has been implemented on FPGA and the image results on the VGA monitor are similar as the simulation on the MATLAB.

***RRIM CLONE—IDENTIFICATION***

Wan Mahzan, K.A. et al.
Empirical investigation of RRIM clone series identification based on visible spectrum using spectrometer
***Paper presented at 19th IEEE Control and System Graduate Research Colloquium (2018) held at Grand Blue Wave Hotel Shah Alam, from 3-4th August***
*Published online: 1 March 2019 IEEE Explore Database*

According to the rapidity of rubber tree sector, the demand of rubber manufacturing product is rising and expected to continue increase all over the world. Thus, the identification of rubber tree clone is important in order to increase the productivity of latex and it is going to be large investment for farmer in rubber tree plantation. There are at least five RRIM clone that have been selected according to Malaysia Rubber Board suggestion. The characteristic of these clones will be examined based on its visible light spectrum properties using MCS 600 spectrometer. Then, the inference analysis of the relationship between color spectrum properties of rubber tree clones and latex are obtained statistically in this work. Therefore, the outcomes of this work have concluded that the proposed technique is able to use for differentiate various rubber tree clones.

***RUBBER BIOSYNTHESIS***

Men, X. et al.
Biosynthesis of natural rubber: current state and perspectives
**Int J Mol Sc (2019) 20(1):** *https://doi.org/10.3390/ijms20010050*

Natural rubber is a kind of indispensable biopolymers with great use and strategic importance in human society. However, its production relies almost exclusively on rubber-producing plants *Hevea brasiliensis*, which have high requirements for growth conditions, and the mechanism of natural rubber biosynthesis remains largely unknown. In the past two decades, details of the rubber chain polymerization and proteins involved in natural rubber biosynthesis have been investigated intensively. Meanwhile, omics and other advanced biotechnologies bring new insight into rubber production and development of new rubber-producing plants. This review summarizes the achievements of the past two decades in understanding the biosynthesis of natural rubber, especially the massive information obtained from the omics analyses. Possibilities of natural rubber biosynthesis in vitro or in genetically engineered microorganisms are also discussed.

Stonebloom, S.H.; Scheller, H.V.
Transcriptome analysis of rubber biosynthesis in guayule (Parthenium argentatum gray)
**BMC Plant Biology (2019) 1(12): 71;**
*https://doi.org/10.1186/s12870-019-1669-2*

Natural rubber is currently produced nearly exclusively from latex of the Para rubber tree, *Hevea brasiliensis*. The desire to reduce the environmental cost of rubber production, fears of pathogen susceptibility in clonal *Hevea* plantations, volatility in the price of natural rubber, and increasing labor costs have motivated efforts to diversify the supply of natural rubber by developing alternative rubber crops such as guayule (*Parthenium argentatum* Gray). In *Hevea,* latex is produced as an exudate following wounding while in guayule, rubber is deposited within the cortical parenchyma and its production is strongly influenced by environmental conditions. Data presented here will be useful in the improvement of guayule as an alternative source of natural rubber and in better understanding the biosynthesis of this critical polymer. In particular, some of the candidate transcription factors are likely to control the rubber biosynthesis pathway and are good targets for molecular breeding or engineering of guayule plants with higher and more consistent production of rubber.

## *SOIL*

Tetteh, E.N. et al.
Rubber and plantain intercropping: effects of different planting densities on soil characteristics
**PLoS One (2019) 14(1);** *https://doi.org/10.1371/journal.pone.0209260*

Two field experiments were conducted at Ellembelle and Jomoro districts in the Western region of Ghana where rubber cultivation is a predominant farming activity. The objective of the study was to assess the effect of rubber and plantain intercropping systems on selected soil properties. The experiment was arranged in a randomized complete block design (RCBD) with 3 replications. The treatments were the sole crop rubber (R), sole crop plantain (P) and three intercrop systems comprising an additive series of plantain: one row of plantain to one row of rubber (PR), two rows of plantain to one row of rubber (PPR) and three rows of plantain to one row of rubber (PPPR). Generally, agroforestry systems improved the soil hydraulic properties considerably, with the highest cumulative infiltration rates of 5.16 and 8.68 cm/min observed under the PPPR systems at the Ellembelle and Jomoro sites, respectively.

## *SOIL EROSION*

Liu, H. et al.
Modelling weed management strategies to control erosion in rubber plantations
**CATENA (2019) 172 : 345-355**

The role of weeds in soil conservation in agroforestry systems has been largely ignored. We used the Land Use Change Impact Assessment (LUCIA) model to simulate the effects of weed management on erosion in rubber plantations (*Hevea brasiliensis Muell. Arg*). In order to quantify the impact of a dynamic, spatially explicit multi-layer plantation structure on erosion processes in agroforestry systems, we updated LUCIA's erosion module. Its new version simulates soil detachment due to rainfall and runoff, considering the separate effects of the tree canopy and surface cover on soil erosion. The updated LUCIA model was calibrated and validated based on an established rubber plantation experiment in Xishuangbanna, Southwest China, to evaluate the impact of different weeding strategies on soil loss.

### *TAPPING PANEL DYRNESS*

Yuan, K. et al.
Identification and analysis of a CPYC-type glutaredoxin associated with stress response in rubber treees
**Forests (2019) 10(2):158:** *https://doi.org/10.3390/f10020158*

Glutaredoxins (GRXs) are a class of small oxidoreductases which modulate various biological processes in plants. Here, we isolated a GRX gene from the rubber tree (*Hevea brasiliensis* Müll. Arg.), named as *HbSRGRX1*, which encoded 107 amino acid residues with a CPYC active site. Phylogenetic analysis displayed that *HbSRGRX1* was more correlated with GRXs from *Manihot esculenta* Crantz. and *Ricinus communis* L. *HbSRGRX1* was localized in the nuclei of tobacco cells, and its transcripts were preferentially expressed in male flowers and in the high-yield variety Reyan 7-33-97 with strong resistance against cold. The expression levels of *HbSRGRX1* significantly decreased in tapping panel dryness (TPD) trees. Furthermore, *HbSRGRX1* was regulated by wounding, hydrogen peroxide ($H_2O_2$), and multiple hormones. Altogether, these results suggest important roles of *HbSRGRX1* in plant development and defense response to TPD and multiple stresses

## LATEX CHEMISTRY & TECHNOLOGY

### *ELECTROMAGNETIC ABSORBER*

Salayong, K. et al.
Electromagnetic absorber made by natural rubber
**IEICE Transactions on Communication (2019) 2:189-196**

This paper proposes fabrication process of a pyramidal electromagnetic (EM) absorber made by natural rubber. The advantage of this research is to generate value-added latex from Thai rubber and to reduce number of chemical absorber by using natural rubber based absorber. The proposed absorber in the research is mainly made from latex with carbon black filler. The proposed absorber is in the form of rubber foam which provides suitable characteristics to serve as an EM absorber. The results of this research are chemical formulas for fabrication of pyramidal rubber foam with carbon black filler. The fabrication cost

is very low when compared to an available commercial absorber. The electrical properties of the proposed EM absorber are measured. Also the reflectivity is measured and compared well with a commercial EM absorber..

## *LATEX PROPERTIES*

Peres, J.B.R.; Pastore, F.J.
Amazon rubber, a potential yet to be rediscovered
**J. Polym Environ (2019) 27:652:** *https://doi.org/10.1007/s10924-019-01381-7*

Natural rubber still has socioeconomic, environmental and technical importance, despite the production of several synthetic similar polymers in the last 70 years. The Amazon Rainforest, the genetic base of *Hevea brasiliensis*, harbors a great diversity of ecosystems that can result in differentiated latex and elastomer molecules, from trees of the same species or other species and varieties of laticifer plants. Even so, there is little research to compare latex and rubber properties produced from native trees and planted clones. In this work, rubber latex was collected from four locations in the Amazon, including the historical places of Boim and Belterra and the most cultivated clone in Brazil, the RRIM 600, from a *Hevea* plantation in the Center-West of Brazil. The following colloid properties were determined: pH, viscosity, particle size, dry rubber content, total solids content, gel content, total lipids, and total proteins. The molecular weight and the main physical and mechanical properties of the rubbers were also determined. Some main results can be highlighted: the rubber sample from Acre, in the extreme Western part of the Amazon, presented the highest molecular weight, while the Belterra sample, from remaining plantations of the Ford Project in Amazon, showed the highest values for mechanical properties. On the other hand, the technical characteristics of the RRIM 600 clone are close to the results obtained for the Boim sample, in Pará, of the micro-region from where Henry Wickham collected the 70,000 seeds in 1876, from which the species was internationally domesticated. The present work is one of the very few studies to have been carried out with latex and rubber of these ancient rubber trees.

Riba, J.R. et al.
Identification of natural rubber samples for high-voltage insulation applications
**Com. Chem Eng (2019) 124:197-205:**
*https://doi.org/10.1016/j.compchemeng.2019.01.016*

Latex presents high variability due to inherent differences among varieties from different countries, producers or crop seasonality. Natural rubber formulations from natural latex, to be used in insulating materials intended for high-voltage applications, require a wide variety of compounding and multitude of industrial processes. These aspects make it very difficult ensuring the same dielectric properties of the final product. At manufacturing level, it is very important to apply strict control processes to ensure that the final product fulfills all quality specifications. In this paper, a promising approach was applied to automatically identify natural rubber samples with suitable dielectric behavior from those with unsuitable dielectric behavior. This approach is based on the study of FTIR spectral data by applying suitable multivariable methods, such as principal component analysis, canonical variate analysis and k-nearest neighbors. The accurate and fast results reported in this work prove the suitability and potential of the proposed approach.

Zapata-Gallego, N.T.; Alvarez-Lainez, M.L.
Effect of the phonological stage in the natural rubber latex properties
**J. Polym Environ (2019) 27(2):364-371:** *https://doi.org/10.1007/s10924-018-1337-x*

Natural Rubber Latex (NRL) from *Hevea brasiliensis* is a material studied because of their industrial applications. For its natural origin, it is possible to find rubber particles, proteins, phospholipids and ashes. These non-rubber content are responsible for the latex colloidal stability. *H. brasiliensis* tree goes through four stages during the year, changing its nutritional requirements and as a result the rubber yield and stability. Most studies have correlated latex characteristics and yield with tree age and clonal origin but none of them with phenological stages. The impact of the phenological stage on the material properties has not been completely identified yet. In this work, the influence of the clonal origin and the phenological stage with the material properties is studied. Thermal behavior, microstructural analysis, morphological study, colloidal stability and rheology are analyzed for FX3864, IAN710 and AIN873 clones during 1 year. NRL is an amorphous material but during the high-yield period, a melting point is observed. Flowering is the stage when phospholipids, protein and isoelectric point are higher. Phenological stages do not affect the rubber, but the main changes are in the non-rubber content

## RUBBER CHEMISTRY & TECHNOLOGY

### *ASPHALT*

Mohd Azahar, N. et al.
Engineering properties of asphalt binder modified with cup lump rubber
**IOP Conference Series: Earth and Environmental Science (2019) 220(1):**

Polymers are being extensively used for modification of asphalt which yields several key benefits over conventional asphalt. Interest in using natural rubber polymer i.e. cup lump in asphalt modification has increased recently due to fluctuation in natural rubber prices and demand for improved asphalt properties. Since this current innovative road building technique is still new and there is limited information available on this topic, more studies are needed for better understanding the cup lump rubber modified asphalt (CMA). Therefore, this study investigates the engineering properties of the rubberised asphalt binder with 5, 10 and 15% cup lump rubber compared to conventional asphalt binder of 60/70 pen. Laboratory tests, i.e. penetration, softening point, ductility, viscosity, loss on heating and storage stability were performed and compared to the specification.

Pais, J. et al.
The effect of prolonged storage time on asphalt rubber binder properties
**Construction and Building Materials (2019) 210:242-255**

This study wants to provide fundamental understanding of prolonged storage time on asphalt rubber binder properties by performing an investigation on the variation of conventional properties, rheology and morphology of four asphalt rubbers maintained at 180°C in low shear for different digestion/storage times up to 48 h. The analysed asphalt rubbers were manufactured by combining two different asphalt
binder grades, pen 35/50 and pen 50/70, with both cryogenic and ambient crumb rubber. Results have shown that keeping asphalt rubber agitated at the above mentioned processing conditions, up to 48 h, is significantly detrimental when an ambient crumb rubber is used, while it seems not to negatively affect the asphalt rubber produced with cryogenic rubber crumbs. Instead, no remarkable change is recorded when asphalt rubbers are produced with the same rubber type and by changing the base asphalt binders,
namely pen 35/50 and pen 50/70.

Porto, M. et al.
Bitumen and bitumen modification: a review on latest advances
**Applied Sciences (Switzerland) (2019) 9(4):742:** *https://doi.org/10.3390/app9040742*

This synthesis explores the state-of-the-knowledge and state-of-the-practice regarding the latest updates on polymer-modified bitumens (PmBs). The information in this study was gathered from a thorough review of the latest papers in the literatures related to modified bituminous materials, technologies, and advances. For this purpose, the paper is presented in two principle sections. In the first part, the bitumen itself is investigated in terms of chemical structure and microstructural systems. In the second part, the paper focuses on bitumen modification from different aspects for assessing the effectiveness of the introduced additives and polymers for enhancing the engineering properties of bitumen in both paving and industrial applications. In conclusion, the knowledge obtained in this study has revealed the importance of the chemical composition of base bitumen for its modification. It can be declared that while some polymers/additives can improve one or some aspects of neat bitumen properties, they can lead to compatibility problems in storage and production. In this respect, several studies showed the effectiveness of waxes for improving the compatibility of polymers with bitumen in addition to some benefits regarding warm mix asphalt (WMA) production.

## *DAMPING PERFORMANCE—SEISMIC DESIGN*

Okui, Y. et al.
Seismic response of isolated bridge with high damping rubber bearings: self-heating effect at subzero temperatures
**Steel Construction (2019) 12(1):2-9:**
*https://www.onlinelibrary.wiley.com/doi/epdf/10.1002/stco.201800029*

*Kurita-Albrecht Best Scientific Paper Award – Steel at 12th Japan German Bridge Symposium, September 2018 in Munich*

The temperature dependence of the mechanical behaviour of high damping rubber bearings (HDRBs) was investigated by way of cyclic loading tests at different ambient temperatures. As the number of loading cycles increased, so the difference between the ambient and internal temperatures of HDRBs

increased due to self-heating, especially in subzero environments. It was found that the mechanical behaviour of HDRBs is governed by their internal temperatures, not by the ambient temperatures. A simple method for estimating the internal temperature is proposed. Previous cyclic loading tests results at different ambient temperatures have been re-examined based on the internal temperatures obtained from the proposed internal temperature estimation method. The temperature dependence of HDRBs is summarized in terms of the internal temperatures. The conventional temperature dependence based on the ambient temperature may underestimate the seismic response of bridges with HDRBs, especially for subzero environments.

## *ELASTOMERS*

Dargahi, A.; Rakheja, S.; Sedaghati, R.
Development of a field dependent Prandtl-Ishlinskii model for magnetorheological elastomers
**Materials & Design (2019) 166**; *https://doi.org/10.1016/j.matdes.2019.107608*

Magnetorheological elastomers (MREs) offer real-time controllable stiffness and damping properties, and strong hysteresis in the stress-strain responses that depends on magnetic field intensity, strain amplitude and strain rate in a highly nonlinear manner. Prediction of hysteretic stress-strain behavior is essential for effective designs of controllable MRE-based devices. This study presents a stop operator-based Prandtl-Ishlinskii (PI) model for predicting nonlinear hysteresis properties of MREs as functions of the strain amplitude, excitation frequency and magnetic flux density. The stress-strain properties of a MRE fabricated with 40% volume fraction iron particles were experimentally characterized in the shear mode under broad ranges of strain amplitude (2.5–20%), excitation frequency (0.1–50 Hz) and magnetic flux densities (0–450 mT). Subsequently, a stop operator-based classical PI model was formulated considering only 10 hysteresis operators, which required identification of only four parameters. The validity of the classical PI model was assessed using the laboratory-measured data. The proposed classical model is further generalized to enable predictions of MRE dynamic behavior independent of the loading conditions, which would be beneficial for developments in controllable MRE-based adaptive devices. The results demonstrated that the generalized model could accurately characterize nonlinear hysteresis properties of the MRE under the ranges of loading conditions and magnetic field considered.

Yu, G.J. et al.
The mechanical properties of a smart compression-type isolator based on magnetorheological gel and magnetorheological elastomer
Adv Mat Sc and Eng. (2019); *https://doi.org/10.1155/2019/7976580*

In order to control the vibration of civil building structures, a smart extrusion-type isolator was developed based on magnetorheological gel (MRG) and magnetorheological elastomer (MRE). The key technology and performance tests of the isolator were investigated as well as the identification of parameters of the mechanical model. Test results showed that the MRG cylinder has a damping characteristic at high frequency while the MRE cylinder has an isolation characteristic at low frequency. The designed isolator is therefore superior over the traditional isolator since it will show small damping and low dynamic stiffness at a high frequency and small amplitude situation, which can overcome stiffness hardening that occurs on the traditional isolator. Meanwhile, the designed isolator will also have the behavior of large isolation and high dynamic stiffness under the low frequency and large amplitude condition, which has the advantage of realizable displacement control. The uniaxial mechanical model for the MRG/MRE smart isolator was built, and the parameters of the designed vibration isolator were identified. Theoretical results obtained from the mechanical model of the MRG/MRE smart isolator agree well with the experimental results indicating that the parameter identification method is feasible and effective.

Yunus, N.A. et al.
Thermal stability and rheological properties of epoxidized natural rubber-based magnetorheological elastomer
**Int. J. of Mol. Sc. (2019) 20(3):746:** *https://doi.org/10.3390/ijms20030746*

Determination of the thermal characteristics and temperature-dependent rheological properties of the magnetorheological elastomers (MREs) is of paramount importance particularly with regards to MRE applications. Hitherto, a paucity of temperature dependent analysis has been conducted by MRE researchers. In this study, an investigation on the thermal and rheological properties of epoxidized natural rubber (ENR)-based MREs was performed. Various percentages of carbonyl iron particles (CIPs) were blended with the ENR compound using a two roll-mill for the preparation of the ENR-based MRE samples. The morphological, elemental, and thermal analyses were performed before the rheological test. Several characterizations, as well as the effects of the strain amplitude, temperature, and magnetic field on the rheological properties

of ENR-based MRE samples, were evaluated. The micrographs and elemental results were well-correlated regarding the CIP and Fe contents, and a uniform distribution of CIPs was achieved. The results of the thermal test indicated that the incorporation of CIPs enhanced the thermal stability of the ENR-based MREs. Based on the rheological analysis, the storage modulus and loss factor were dependent on the CIP content and strain amplitude. The effect of temperature on the rheological properties revealed that the stiffness of the ENR-based MREs was considered stable, and they were appropriate to be employed in the MRE devices exposed to high temperatures above 45 °C.

***EMULSION POLYMERIZATIONS***

Cummings, S. et al.
On the use of starch in emulsion polymerizations
**Processes (2019) 7(3):140;** *https://doi.org/10.3390/pr7030140*

The substitution of petroleum-based synthetic polymers in latex formulations with sustainable and/or bio-based sources has increasingly been a focus of both academic and industrial research. Emulsion polymerization already provides a more sustainable way to produce polymers for coatings and adhesives, because it is a water-based process. It can be made even more attractive as a green alternative with the addition of starch, a renewable material that has proven to be extremely useful as a filler, stabilizer, property modifier and macromer. This work provides a critical review of attempts to modify and incorporate various types of starch in emulsion polymerizations. This review focuses on the method of initiation, grafting mechanisms, starch feeding strategies and the characterization methods. It provides a needed guide for those looking to modify starch in an emulsion polymerization to achieve a target grafting performance or to incorporate starch in latex formulations for the replacement of synthetic polymers.

***NITRILE RUBBER***

Yew, G.Y. et al.
Emerging crosslinking techniques for glove manufacturers with improved nitrile glove properties and reduced allergic risks
**Materials Today Communications (2019) 19:39-50:**
*https://doi.org/10.1016/j.mtcomm.2018.12.014*

The long revolution of nitrile rubber in the rubber industries, especially for lightly crosslinked products has been reviewed in this paper. The advancement is remarkable from the first invention of acrylonitrile butadiene rubber and till date, the physical and chemical properties were elevated. Recent rubber chemists are mainly focus in modifying the nature of the synthetic latex based on butadiene and crosslinker to enhance the performability for rubber product to be used in broad range of applications. Besides, the different types of rubber had contribute to different sectors of usage due to their speciality properties. All belong to the effort of various types of crosslinking methods which making the liquid latex to suit in plenty of applications and usage from space shuttle (O-ring) to food hawker hygiene gloves. This paper summarized all sort of gloves products in comparison with nitrile rubber glove. Natural rubber is a superior latex glove which show high elasticity and tactility however not suitable for medical usage due to its protein allergic issues. Moreover, current development of natural rubber by synthesis through, in vitro and in vivo method, with the aim to produce equivalent properties of rubber product with lower materials cost. In fact, the glove manufacturing process have various parameters to monitor to produce a accepted quality of gloves. A quality of nitrile glove may need to pay close attention on latex compounding formulation and choice of the value-added process options. Metal ions crosslinker shows an exceptional cost and time saving for crosslinking especially on nitrile rubber. The discussion on the bonding characteristic which contribute for the tensile strength and durability of the nitrile rubber glove.

## *RECYCLED RUBBER -- APPLICATIONS*

Mathew, A. S.
Rubber/tyre recycling new innovations promise better results
**Rubb. Asia 2019: March-April**

Rubber recycling is the process of converting end-of-life or worn-out old tyres, tubes etc. into material that can be utilized in new products. New innovations in recycling promises better results and ensure a sustainable future for the rubber industry. With minimum number of experiments, it enables the study of the effect of individual factors with different levels and the effect due to the interaction between the factors on the product.

Seghar, S. et al.
Thermo-mechanical devulcanization and recycling of rubber industry waste
**Resources, Conservation and Recycling (2019) 144:180-189**;
https://doi.org/10.1016/j.resconrec.2019.01.047

This work is focused on the recycling of natural rubber industry waste by means of thermo-mechanical devulcanization. With that aim, tests were carried out in an industrial twin-screw extruder, at different barrel temperatures, ranging from 80 to 220 °C. The extrusion was done with a screw profile specifically designed for the devulcanization process. The extent and quality of devulcanization were evaluated through the measurements of crosslink density, soluble fraction and Mooney viscosity, and by using the Horikx diagram. Results showed that a high degree of reclaiming (˜90%) was obtained, independently of the barrel temperature. The samples with the best devulcanization quality, i.e. the samples with a more selective sulfur bond scission, were found to be those treated at a lower input temperature. This was explained by the effect of the rubber homogenous self-heating which contributes to the local increase of the material temperature, during the devulcanization process. Moreover, it was found that the properties of the devulcanized rubber/virgin rubber blends were not significantly affected by the addition of the treated rubber. Results suggest that the entire natural rubber industry waste could be recycled into new competitive products, with low energy consumption. This would present a real contribution to the industrial recycling and thus a noticeable improvement of the environment.

van Hoek, J.W.; Heideman, G.; Noodermeer, J.W.M.. et al
Implications of the use of silica as active filler in passenger car tire compounds on their recycling options
**Materials (2019) 12(5):725**

Tires are an important vehicle component, as car handling, safety and fuel economy depend for a major part on the tire composition and construction. As a consequence, tires are improved continuously. The most prominent improvement in the recent past was the use of a silica-silane filler system in passenger car tread compounds, instead of traditionally used carbon black. For recycling and re-use of end-of-life car tire rubber one of the most promising recycling methods is devulcanization: re-plasticizing the vulcanized rubber by selectively breaking the sulfur bridges between the polymer molecules. In the present paper, the influence of silica, which is present in the passenger car tires granulate, on both

devulcanization and subsequent revulcanization, is investigated. In a step-wise approach it is shown that the presence of silica influences both devulcanization and revulcanization. The best tensile strength of the revulcanizate, using a carbon-black-based revulcanization formulation, was 5 MPa. This could be improved to 6.5 MPa by using 2.8 phr of 1,3-DiPhenylGuanidine (DPG) in the revulcanization formulation. After addition of a silanization step during revulcanization by adding 3.2 phr bis[3-(TriEthoxySilyl)Propyl] Tetrasulfide (TESPT), a silane, to the formulation, the tensile strength of the revulcanizate was further improved to 8 MPa. With these results it is shown that the silica in the granulate can be used to improve the revulcanization properties. To check the benefits of using pure tire tread material for the devulcanization and subsequent revulcanization, of both a carbon black and a silica-based virgin tread compound, it is shown that a tensile strength of the revulcanizate of 13 MPa can be reached. This shows the potential of devulcanized rubber when the various tire components are separated before whole car tire material is granulated as the beginning of the recycling.

## *REINFORCED PLASTICS*

Faibunchan, P. et al.
Influence type of natural rubber on properties of green biodegradable thermoplastic natural rubber based on poly(butylene succinate)
**Polymers Adv Techn (2019) 30(4):1010-1026;** *https://doi.org/10.1002/pat.4534*

Green biodegradable thermoplastic natural rubber (GB-TPNR) based on simple blend of natural rubber (NR) and poly(butylene succinate) (PBS) was prepared using three NR alternatives: unmodified NR and epoxidized NR with 25- or 50-mol% epoxide (ie, ENR-25 or ENR-50). It was found that ENR-50/PBS blend showed the best compatibility, which resulted in superior mechanical and thermal properties with the highest crystallinity of the PBS phase, on comparing with the ENR-25/PBS and NR/PBS blends. This might be attributed to stronger chemical interactions between the epoxide groups in ENR-50 and the polar functional groups in PBS, which were confirmed by Fourier transform infrared (FTIR). Furthermore, scanning electron microscopy (SEM), atomic force microscopy (AFM), and polarizing optical microscopy (POM) micrographs of ENR-50/PBS blend revealed phase separation with finer-grained cocontinuous structure than

in ENR-25/PBS and NR/PBS simple blends. Furthermore, the chemical interactions in ENR-50/PBS blend enhanced the resistance to accelerated weathering.

## *RUBBER NANOCOMPOSITES*

Bokobza, L.
Natural rubber nanocomposites: a review
**Nanomaterials (2019) 9(1):12; https://doi.org/10.3390/nano9010012**

This paper reviews studies carried out on natural rubber filled with nanofillers such as spherical silica particles (generated by the sol gel reaction), clays and carbon nanostructures. It is shown that the mechanical response of NR is influenced by several parameters including the processing conditions, the state of filler dispersion, the polymer-filler interactions and the filler morphological aspects. Even if the sol gel process conducted in vulcanized rubber yields almost ideal dispersions, rod-shaped particles such as clay, carbon fibers or carbon nanotubes are by far more efficient in terms of mechanical reinforcement on account of their anisotropic character and their ability to orientate in the direction of stretch. The efficiency of layered fillers such as clays or graphitic structures clearly depends on the way they are dispersed (exfoliated) in the rubber. Complete exfoliation still remains difficult to achieve which limits the tremendous nanoreinforcement expected from a single layer of clay or graphite. In all cases, the onset of crystallization is observed at a lower strain value than that of the unfilled matrix due to strain amplification effects.

Capezza, A. et al.
Preparation and comparison of reduced graphene oxide and carbon nanotubes as fillers in conductive natural rubber for flexible electronic.
**ACS Omega (2019) 4):3458-3468**

Conductive natural rubber (NR) nanocomposites were prepared by solvent-casting suspensions of reduced graphene oxide (rGO) or carbon nanotubes (CNTs), followed by vulcanization of the rubber composites. Both rGO and CNT were compatible as fillers in the NR as well as having sufficient intrinsic electrical conductivity for functional applications. Physical (thermal) and chemical reduction of GO were investigated, and the results of the reductions were monitored by X-ray photoelectron spectroscopy for establishing a reduction protocol that was useful for the rGO nanocomposite preparation. Field-emission

scanning electron microscopy showed that both nanofillers were adequately dispersed in the main NR phase. The CNT composite displays a marked mechanical hysteresis and higher elongation at break, in comparison to the rGO composites for an equal fraction of the carbon phase. Moreover, the composite conductivity was always ca. 3–4 orders of magnitude higher for the CNT composite than for the rGO composites, the former reaching a maximum conductivity of ca. 10.5 S/m, which was explained by the more favorable geometry of the CNT versus the rGO sheets. For low current density applications though, both composites achieved the necessary percolation and showed the electrical conductivity needed for being applied as flexible conductors for a light-emitting diode.

Krainoi, A. et al.
Influence of carbon nanotube and ionic liquid on properties of natural rubber nanocomposites.
**Express Polymer Letters (2019) 13(4) : 327-348**

Some properties of carbon nanotube (CNT) filled natural rubber (NR) composites were improved by adding an ionic liquid (IL), 1-butyl-3-methyl imidazolium bis (trifluoromethylsulphonyl)mide (BMI). In this work, the CNT and IL (CNT-IL) were mixed with NR by latex mixing method. Cure characteristics, thermo-mechanical properties, Payne effect, electrical conductivity and thermal stability were investigated. It was found that IL (BMI) accelerated vulcanization reactions and reduced scorch time. In addition, Fourier Transform Infrared (FTIR) results confirmed the role of IL in NR composites along with the reaction between CNT and NR molecules. The temperature scanning stress relaxation (TSSR) measurement was used to assess thermo-mechanical properties, and a relaxation peak of IL was found due to interactions of cations and anions in IL (BMI). Furthermore, the Payne effect was used to qualitatively analyze the roles of IL and CNT in three-dimensional CNT networks in the NR matrix. It was found that CNT dispersion was finer in the NR/CNT composites with IL. Furthermore, the NR/CNT-IL composite had higher electrical conductivity and lower percolation threshold concentration than the NR/CNT composite.

Sanchez-Hidalgo, R. et al.
Multifunctional silicone rubber nanocomposites by controlling the structure and morphology of graphene materials.
**Polymers (2019) 11(3):449: https://doi.org/10.3390/polym11030449**

Multifunctional elastomer nanocomposites have been applied in several high-tech fields. The design of materials with tailored properties capable of tuning their performance is a topical challenge. Here, we demonstrate that it is possible to modulate the mechanical and transport properties of silicone rubber nanocomposites by controlling the structure, chemical composition and morphology of the graphene material. Intrinsic graphene properties, such as remaining oxygen groups, specific surface area, and aspect ratio, among others, have a profound effect on the final properties of the nanocomposite. Thus, the thermal conductivity benefits from larger filler size and high aromatic restoration. Whereas mechanical properties and electrical conductivity require a proper balance between filler/polymer matrix interaction and a partial aromatic restoration

***RUBBER PROPERTIES--MODIFICATION***

He, S. et al.
Effect of concentration on properties of vacuum coagulated natural rubber latex
**IOP Conference Series: Earth and Enviromental Science (2019) 233(2)**

Vacuum treatment was used to coagulate natural latex, the effects of latex concentration on physical and chemical properties, mechanical properties, molecular weight and crosslink density of vacuum coagulated natural rubber latex (NRL) were investigated. Studies have shown that with the increase of latex coagulated concentration, the nitrogen content of natural rubber (NR) increases and the ash content decreased. In the range of coagulated concentration studied, the plasticity initial value ($P_0$) and plastic retention rate (PRI) ratio of low concentration solidified raw rubber were higher than high concentration of NR. The tensile strength of NR decreased with the increase of solidification concentration. The molecular weight have shown a bimodal distribution, and the number average molecular weight (Mn), weight average molecular weight (Mw), and z average molecular weight (Mz) increased with the solidification concentration of latex, and the dispersion coefficient decreased. With the increase of solidification concentration, the crosslink density of NR decreased first and then increased. The relative molecular mass (Mc) of the rubber cross-linking point increased first and then decreased with the increase of solidification concentration.

Mastowski, M.; Miedzianowska, J.; Strzelec, K.
Silanized cereal straw as a novel, functional filler of natural rubber biocomposites
**Cellulose (2019): 26(2): 1025-1040: https://doi.org/10.1007/s10570-018-2093-8**

The aim of the presented research paper was to modify the biofiller in the form of milled cereal straw with 3-aminopropyl(diethoxy)methyl silane, and apply it to the natural rubber. To determine the material properties, an in-depth characterization of both the treated lignocellulosic material and the composites was studied. On the basis of thermogravimetric analysis, scanning electron microscopy, infrared spectroscopy and analysis of contact angle measurements, it was found that the silanization process significantly influenced thermal stability and hygroscopicity of the straw, its hydrophobicity as well as dispersion in polymeric matrix. Analyses of the new composites included static and dynamic mechanical properties, hardness, and barrier and damping properties, all of which showed improvement. This was because of improved interactions at the filler–elastomer, which resulted from better adhesion of the treated bio-additive to natural rubber. Biocomposites have also demonstrated greater resistance to flammability as well as thermo-oxidative aging processes. The research clearly indicates the application potential of these new multifunctional and biocompatible materials.

Olsen, C.; Thornburg, B.; Sharp, E.
Improving low temperature properties in a silicone elastomer
**Rubber & Plastics News March, 11 2019**

This article describes the investigation and commercialization of a specific compound intended for a cryogenic seal application. A hypothesis to account for the improvement in low-temperature performance is discussed and extended to other potential chemistries and applications. It is well known in the elastomers industry that dimethyl silicone elastomers exhibit a dramatic increase in their modulus at temperatures at about -40°C. Historically, phenyl substituted dimethyl siloxane polymers (PVMQ) have been used to achieve consistent mechanical properties in silicone elastomers at these low temperatures. We have found that improved low temperature properties can be achieved through incorporation of a medium viscosity, vinyl terminated diphenyl dimethyl copolymer into a conventional vinyl dimethyl gum (VMQ). This modified VMQ gum was combined with filler and processed into a low temperature base. The low temperature base was combined with additional VMQ high consistency rubber base and catalyst for

molding into test articles and finished seals. The effect on the mechanical properties were assessed for a range of viscosities of the vinyl diphenyl dimethyl copolymer, for the degree of phenyl substitution on the copolymer, for the base processing and catalyst choices for the compound.

Olsen, C.; Thornburg, B.; Sharp, E.
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***RUBBERISED PAVEMENTS***

Licitra, G., Moro, A., Teti, L., Del Pizzo, A., Bianco, F.
Modelling of acoustic ageing of rubberized pavements
**Applied Acoustics (2019) 146:237-245**
**https://doi.org/10.1016/j.apacoust.2018.11.009**

Tyre-road noise is the most important source of traffic noise in the mid-to-high speed range. The use of low noise road surfaces represents an ideal solution to mitigate traffic noise, because it directly affects the source, generating a widespread benefit for all the dwellings near the road and decreasing the number of people annoyed. More knowledge about long-term acoustic performance is required to promote the use of low noise road surfaces as mitigation action. In fact, as for a traditional road surface, the acoustic properties of low noise surfaces worsen over time: only by knowing the initial noise reduction and its time evolution, public administrations can design their application and related maintenance plans.

## TYRES

### *ABRASION*

Dayang Habibah Abang Ismawi Hassim et al.
The effect of interface morphology in waste tyre rubber powder filled elastomeric matrices on the tear and abrasion resistance
**Express Polymer Letters (2019) 13(3):248-260**

The interface between either Micronised Rubber Powder (MRP) or Crumb Rubber Powder (CRP) fillers in either Natural Rubber (NR) or Butadiene Rubber (BR) matrices has been studied using Transmission Electron Microscopy (TEM) 'network visualisation'. The convoluted structure of CRP provides better interfacial adhesion than MRP. The weak interface between the MRP networks and the rubber matrix was confirmed by the lower physical bonding. The crescent tear strength test was able to characterise the possible weak interaction of MRP in unfilled NR or NR/BR blend matrix. The Akron test was used for carbon black-filled matrix.

Salehi, M. et al.
Measuring rubber friction using a Laboratory Abrasion Tester (LAT100) to predict car tire dry ABS braking
**Tribology International (2019) 131:191-199**

Evaluating tire grip on the road, an extremely complicated tribological system, is enormously energy and time consuming but essential for safety. To predict grip on the road, tires with four different tread compounds were tested on ABS braking distance on a dry test track. Corresponding solid rubber wheels were characterized on the Laboratory Abrasion Tester (LAT100) on four different electro-corundum discs of various grain sizes. With increasing speed the side force coefficient (SFC) decreases. A lower disc grain size induces a higher SFC. A correlation coefficient of 0.93 between the LAT100 data and road results for the four tread compounds has a high potential for predicting the car tire ABS braking distance.

***RECLAIMED TYRE***

Phiri, M.M. et al
Effect of free foaming and pre-curing on the thermal, morphological and physical properties of reclaimed tyre rubber foam composites
**J of Cleaner Production (2019) 218:665-672**

Foaming of rubber is a well-known technique and foamed rubber products have found application in various industries including cushioning, heat insulation and sound absorption. In the current study, the foaming of reclaimed tyre rubber (RTR), as an alternative to virgin rubber, is explored. The effect of varying the amounts of waste ethylene vinyl acetate (filler), sodium bicarbonate (blowing agent) and dicumyl peroxide (co-curative) on the RTR properties was studied. Composites formulations were obtained by use of the simplex-lattice mixture design and the samples were prepared by following two foaming techniques namely, prepressing and free foaming. Hardness of free foamed samples was found to be lower than that of prepressed samples, owing to effective foaming and the formation of multiple microcells in the former. An increase in blowing agent content resulted in decreased density and thermal stability of the foamed composites. Dicumyl peroxide caused an increase in density but had no effect on thermal stability. The incorporation of a filler in formulations effected an increase in the gel content and thermal stability of the foams.

***TIRES – RECYCLING***

Buan, A.
A fresh look at recovery solutions for old tyres
**Rubb J Asia (2019) March/April: 3-4**

Tyre that have seen better days may be imputed as pollution contributors, however new developments are changing this notion about end of life tyres (ELTs).

Pote, R.N.; Patil, R.K.
Combustion and emission characteristics analysis of waste tyre pyrolysis oil
**SN Applied Sciences (2019) 1:294;** *https://doi.org/10.1007/s42452-019-0308-8*

The need of the substitute fuels in compression ignition engines has been the major requisite of the today's world. Due to progressive diminution in crude oil and their subsequent environmental effects many researchers are working on various alternative fuels like biodiesel, methanol, alcohols, CNG, LPG, biogas. Fulfillment of the stringent emission norms is also a great concern as the fuel suggested should also offer the desired performance and should be economically and environmentally proven. Hence the oil extracted from the waste tyre is the biggest emanating fuel tested for its behavioral analysis when blended with diesel on single cylinder Variable compression ratio diesel engine.

## *TIRES – ROLLING RESISTANCE*

Behroozinia, P.; Taheri, S.; Mirzaeifar, R.
Tire health monitoring using the intelligent tire concept
**Structural Health Monitoring (2018) 18(2):390-400**

Tire durability plays an important role in road transportation safety. Damaged tires can cause vehicle instability and create potential traffic accidents. To study the potential of using the intelligent tire concept for health monitoring of the tire, a computational method for defect detection in tire structure was developed. Comparing the trend of acceleration signals for the undamaged and damaged tires can reveal information about the crack length and location around the tire circumference. To accomplish this, a finite element model of the intelligent tire was developed using implicit dynamic analysis. In addition, using the data from the model, a health monitoring algorithm was developed for predicting the crack locations using the acceleration signals obtained from the tri-axial accelerometer attached to the tire inner-liner. It is observed that the radial component of the acceleration signal plays a key role in defect detection in intelligent tires.

## OTHERS

### *AGRONOMIC PRACTICES*

Andersson, J.A.; Giller, K.E.
Doing development-oriented agronomy: rethinking methods, concepts and direction
**Expl. Agric. (2019) 55(2):157-162**

This special issue brings together a selection of papers that not merely present agronomic research findings, but critically review orientations, methodologies and research practices in agronomy. The focus is on agronomic research as it conducted as component of rural development efforts in the global South or, in short, development oriented agronomy. Aiming to contribute to development challenges like food security, human welfare and wellbeing, and environmental sustainability, a focus on development-oriented agronomy implies a step beyond a narrow understanding of agronomy as the science of crop production and soil management. Doing development-oriented agronomy forefronts the juggling with productivity enhancing, environmental and social developmental goals entailed when doing agronomy. What is more, development-oriented agronomy generally takes place within a complex environment of (inter)national research and development policy organisations, development donor-funded projects, governmental, NGO and private sector agencies and global professional networks and (public–private) partnerships. Consequently, development-oriented agronomy is a field where debate and contestations over goals and direction, research methodologies and findings of agronomic research are first likely to emerge and become apparent.

Vrignon-Brenans, S. et al.
Nutrient management of immature rubber plantations. A review
**Agron. Sustain. Dev. (2019) 39:11: https://doi.org/10.1007/s13593-019-0554-6**

The rapid expansion of rubber tree plantations in recent decades has been accompanied by dramatic negative ecological and social impacts. Rubber sector stakeholders consequently engaged in sustainable production of rubber. Despite the lack of harvest during the immature stage following planting, this period plays a key role in future yields. Management practices, particularly fertilization

regimes, are used by farmers to shorten the immature period as much as possible. This entails maintaining or even improving the productivity of existing plantations to face the demand for natural rubber. This review focuses specifically on the immature period of rubber tree plantations, as it is the most critical period for nutrient management. We reviewed available knowledge on fertilization practices, soil management, and nutrient dynamics in rubber plantations with the goal of developing a nutrient balance approach for this crop. Our review revealed (1) a notable difference between fertilizer recommendations made by technical institutes and those reported in the scientific literature; (2) that even though nutrient diagnostic methods could help growers adapt the fertilization of rubber trees more than 3 years of age, further studies are needed to adapt current methods to the wide range of cultivation areas; and (3) that the nutrient budget approach may be the best way to incorporate the variety of rubber tree cultivation conditions. In conclusion, the nutrient budget method is a promising way to improve the sustainability of rubber plantations through fertilization making it possible to increase nutrient use efficiency. A comprehensive approach based on nutrient budgets requires further in-depth studies to examine nutrient dynamics in a wide range of conditions, including intercropping and logging residue management between clear cutting and replanting.

## *CLIMATE CHANGE*

Thellmann, K. et. al
Assessing hydrological ecosystem service in a rubber-dominated watershed under scenarios of land use and climate change
**Forests (2019) 10(2): 179 : https://doi.org/10.3390/f10020176**

Land use and climate change exert pressure on ecosystems and threaten the sustainable supply of ecosystem services (ESS). In Southeast-Asia, the shift from swidden farming to permanent cash crop systems has led to a wide range of impacts on ESS. Our study area, the Nabanhe Reserve in Yunnan province (PR China), saw the loss of extensive forest areas and the expansion of rubber (*Hevea brasiliensis* Mull. Arg.) plantations. In this study, we model water yield and sediment export for a rubber-dominated watershed under multiple scenarios of land use and climate change in order to assess how both drivers influence the supply of these ESS. For this we use three stakeholder-validated land use scenarios, varying in their degree of rubber expansion and land management

rules. As projected climate change varies remarkably between different climate models, we combined the land use scenarios with datasets of temperature and precipitation changes, derived from nine General Circulation Models (GCMs) of the Fifth Assessment Report of the IPCC (Intergovernmental Panel on Climate Change) in order to model water yield and sediment export with InVEST (Integrated Valuation of Ecosystem Services and Trade-offs). Simulation results show that the effect of land use and land management decisions on water yield in Nabanhe Reserve are relatively minor (4% difference in water yield between land use scenarios), when compared to the effects that future climate change will exert on water yield (up to 15% increase or 13% decrease in water yield compared to the baseline climate). Changes in sediment export were more sensitive to land use change (15% increase or 64% decrease) in comparison to the effects of climate change (up to 10% increase). We conclude that in the future, particularly dry years may have a more pronounced effect on the water balance as the higher potential evapotranspiration increases the probability for periods of water scarcity, especially in the dry season. The method we applied can easily be transferred to regions facing comparable land use situations, as InVEST and the IPCC data are freely available.