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Bio-based anti-coagulant agent from microorganisms for natural rubber latex preservation

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BIO-BASED ANTI-COAGULANT AGENT FROM MICROORGANISMS FOR NATURAL RUBBER LATEX PRESERVATION

By

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BIO-BASED ANTI-COAGULANT AGENT FROM MICROORGANISMS FOR NATURAL RUBBER LATEX PRESERVATION

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February 2015

Chairman : Wan Zuhainis Saad, PhD

Faculty : Biotechnology and Biomolecular Sciences

Natural rubber (NR) latex is whitish fluid derived from latex ducts which are in a layer outside the cambium of rubber trees (*Hevea Brasiliensis*). Latex is a stable dispersion of cis-1,4-polyisoprene rubber in an aqueous phase that contain non-rubber substances such as carbohydrates, proteins and amino acids and a range of enzymes. Non-rubber constitute in NR latex encourage the proliferation of bacteria that causes latex destabilization and coagulation due to their metabolism activities. Preserved NR latex is referred to latex that will not undergo coagulation process to form a solid natural rubber. Ammonia and others chemical-based preservative agent such as tetramethylthiuramdisulphite/ zinc oxide (TMTD/ZNO) have negative drawbacks to the environment and human health. The approach on searching for biological based format for NR latex preservation was due to the current focus on generating biologically processing system. Therefore, the objective of the present study is to search for biological based anti-coagulant agent for NR latex short-term preservation with antimicrobial and surfactant properties from microorganisms present in environment related with NR. A total of 28 isolates comprises 20 bacterial isolates and eight fungal isolates were successfully obtained from field NR latex, coagulated NR latex and soil from rubber plantation area. Screening for antimicrobial activity was performed using disc diffusion method. The surfactant activity was evaluated by measuring the surface tension of the extracts. The emulsification capability was determined by measuring the droplets size and distribution of oil in water emulsions. The field NR latex stability was characterized by means of bacterial population, volatile fatty acid numbers (VFA), and NR latex viscosity. Out of 28 isolates, only four isolates exhibited antimicrobial activity namely, *Aspergillus fumigatus* S14, *A. flavus* S16, *Phaeomoniella chlamydospora* EM19 and *Bacillus amyloliquefaciens* S10b. Meanwhile, in surfactant activity screening assay, only five isolates out of 28 isolates exhibited surfactant activity in which comprises of one fungi *Lambdasporium* sp. FS31 and four bacteria (*Enterococcus feacalis* F11, *Myroides odoratus* F5, *Bacillus pumilus* S1b and EM23). Microbial extracts from *B. amyloliquefaciens* S10b performed better than the other isolates that exhibited antimicrobial activity in acting as antimicrobial agent in field NR latex. Surfactant activities from *Lambdasporium* sp. FS31 showed greater potential to enhance the colloidal stability of the rubber particles. Out of the nine isolates, four isolates namely, *P. chlamydospora* EM19, *B. amyloliquefaciens* S10b, *Lambdasporium* sp. FS31 and *M. odoratus* F5 were prepared in a mixture. Field NR latex in the presence of microbial extracts from *B. amyloliquefaciens* S10b with *Lambdasporium* sp. FS31 showed less bacterial activity and slow increment of VFA number resulting in minimal changes of the NR latex viscosity indicated a good NR latex stability. In conclusion, this study showed that these microorganisms have potential to be used as an anti-coagulant agent for NR latex preservation.

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sebagai memenuhi keperluan untuk ijazah Master Sains

AGEN ANTI-PENGGUMPALAN BERASASKAN BIOLOGI DARIPADA MIKROORGANISMA UNTUK PENGAWETAN LATEKS GETAH ASLI

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Lateks getah asli (GA) merupakan cecair putih yang dihasilkan daripada saluran lateks yang merupakan lapisan luaran kambium pokok getah (*Hevea Brasiliensis*). Lateks adalah penyebaran stabil cis-1,4-polyisoprene getah di dalam fasa bendalir yang mengandungi komponen selain getah seperti campuran karbohidrat, protein dan asid amino dan pelbagai enzim. Komponen ini menggalakkan pembiakan bakteria yang menyebabkan ketidakstabilan lateks kesan daripada aktiviti metabolisma. Lateks GA yang diawet merujuk kepada lateks yang tidak melalui proses pembekuaan bagi menghasilkan lateks yang stabil. Ammonia dan agen pengawetan berasaskan kimia yang lain seperti tetramethylthiuramdisulfida/ zink oksida (TMTD/ZnO) memberi kesan negatif kepada alam sekitar dan kesihatan manusia. Oleh itu, pencarian bahan pengawet yang berasaskan biologi merupakan langkah yang diambil berdasarkan matlamat untuk menghasilkan sistem pemprosesan hijau. Oleh itu, objektif kajian ini adalah untuk mencari sebatian anti-penggumpalan untuk pengawetan lateks GA dalam jangka masa pendek yang berasaskan biologi dengan sifat-sifat antimikrob dan surfaktasi daripada hasil ekstrak mikroorganisma yang diperolehi daripada kawasan sekitar yang melibatkan GA. Sejumlah 28 mikroorganisma terdiri daripada 20 jenis bakteria dan 8 jenis fungi telah berjaya diperolehi daripada lateks GA, lateks beku dan tanah dari kawasan tanaman getah. Saringan terhadap aktiviti antimikrob daripada ekstrak mikroorganisma telah dijalankan dengan menggunakan kaedah resapan agar. Manakala saringan aktiviti surfaktasi dijalankan dengan mengukur kadar ketegangan permukaan air dengan kehadiran ekstrak mikroorganisma tersebut. Keupayaan emulsifikasi ekstrak mikroorganisma tersebut pula ditentukan dengan mengkaji pengedaran dan saiz titik kecil yang terbentuk daripada proses emulsifikasi minyak di dalam air. Kestabilan lateks GA dicirikan melalui kandungan bakteria didalam lateks GA, pembentukan asid lemak meruap dan kelikatan lateks GA. Daripada sejumlah 28 jenis mikroorganisma, hanya empat sahaja yang menunjukkan sifat antimikrob iaitu *Aspergillus fumigatus* S14, *A. flavus* S16, *Phaeomoniella chlamydospora* EM19 dan *Bacillus amyloliquefaciens* S10b. Manakala, daripada saringan aktiviti surfaktasi hanya lima mikroorganisma yang terdiri daripada satu fungi *Lambdasporium* sp. FS31 dan empat bakteria (*Enterococcus feacalis* F11, *Myroides odoratus* F5, *Bacillus pumilus* S1b dan EM23) yang menunjukkan sifat surfaktasi. Ekstrak mikroorganisma daripada bakteria *B. amyloliquefaciens* S10b menunjukkan aktiviti antimikrob yang lebih baik berbanding mikroorganisma yang lain yang menunjukkan aktiviti yang sama. Aktiviti surfaktasi daripada ekstrak *Lambdasporium* sp. FS31 pula, menunjukkan potensi untuk meningkatkan kestabilan koloid antara zarah-zarah getah didalam lateks GA. Daripada sembilan jenis mikroorganisma yang terdiri daripada empat mikroorganisma dengan ciri-ciri antimikrob dan lima mikroorganisma dengan ciri-ciri surfaktasi, hanya empat mikroorganisma iaitu *P. chlamydospora* EM19, *B. amyloliquefaciens* S10b, *Lambdasporium* sp. FS31 dan *M. odoratus* F5 dipilih dan disediakan di dalam bentuk campuran. Lateks GA yang dicampurkan dengan campuran daripada ekstrak *B. amyloliquefaciens* S10b bersama *Lambdasporium* sp. FS31 menunjukkan kadar aktiviti bakteria yang kurang dan peningkatan kadar asid lemak meruap yang perlahan. Seterusnya menyebabkan perubahan yang tidak ketara dalam kadar kelikatan lateks GA yang merupakan petunjuk kepada kestabilan lateks GA yang baik. Kesimpulannya, kajian ini menunjukkan hasil daripada ekstrak mikroorganisma mempunyai potensi untuk digunakan sebagai bahan anti-penggumpalan untuk pengawetan lateks GA.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS/SYMBOLS

<	Less than
=	Equal
>	More than
%	Percentage
µg	Microgram
µL	Microliter
µm	Micrometer
ABC	Assisted biological coagulation
ATCC	American Type Culture Collection
BA	Boric acid
C	Carbon
Cfu/mL	Cell forming unit per mililiter
Cp	Centripoise
CMC	Critical micelles concentrations
d	Day
DA	De-ammoniated latex
DMSO	Dimethyl sulphoxide
DNA	Deoxyribonucleic acid
DRC	Dry rubber content
EUCAST	European Committee for Antimicrobial Susceptibility Testing
Fe	Ferum
g	Gram
g/L	Gram per liter
h	Hour
H	Hydrogen
HA	High ammoniated
K	Potassium
L	Liter
LA	Low ammonia
LA-TZ	Low ammonia - tetramethylthiuram disulphide, zinc oxide
LPS	Lipopolysaccharide
MBC	Minimum bactericidal concentration
Mg	Magnesium
MHA	Muller-Hinton Agar
MIC	Minimum inhibition concentration
min	Minutes
mL	Mililiter
mm	Milimeter
mN/m	Mili Newton per meter
mRNA	Messenger ribonucleic acid
MST	Mechanical stability time
MYEA	Molasses yeast extract agar
N	Nitrogen
NC	Negative control
NCCLS	National Committee for Clinical Laboratory Standards
nm	Nanometer
NH_3	Ammonia
NR	Natural Rubber

O	Oxygen
OD	Optical density
^oC	Celcius
P	Phosphorus
PC	Positive control
PDA	Potato dextrose agar
phr	Parts per hundred
PRBL	Atriazine/benzotriazole derivative
PRI	Plasticity Retention Index
rpm	Revolution per minit
S	Sulphur
SD	Standard deviation
SDS	Sodium dodecyl sulphate
SLS	Sodium laurate sulphate
SPP	Sodium pentachlorphenate
sp.	Species
T_i	Surface excess concentration
TMTD	Tetramethylthiuram disulphide
TSA	Tryptic soy agar
TSB	Tryptic soy broth
TSC	Total solid content
VFA	Volatile fatty acid
Wt%	Weight percent
ZDC	Zinc diethyldithiocarbamate
ZnO	Zinc oxide
$ZnSO_4$	Zinc sulphate

CHAPTER 1

INTRODUCTION

Natural rubber (NR) latex is derived from latex ducts which are in a layer outside the cambium of rubber trees (*Hevea brasiliensis*) (John, 1982). When the tree bark is tapped, a milky fluid which comprising 30% - 40% of rubber hydrocarbon particles with a few percentage of non-rubber particles such as proteins, lipids, carbohydrates and sugars are immediately flow through the tapping panel on the tree bark and into the collecting cup (Angrove, 1964). The remaining major component of NR latex is water. In addition to rubber and water, latex contains small quantities of proteins, fatty acids, sterols, lipids, carbohydrates and other mineral matters (Hasma and Subramaniam, 1986). Due to mineral rich in latex serum, microorganisms were prone to propagate and used these substances as their energy sources (Taysum, 1960).

Natural rubber latex is contaminated with microorganisms after being tapped (Taysum, 1960). The main sources of contamination of field NR latex are the tree lace, tapping panel bark and the cup which receives the latex (Soeseno and Mansjoer, 1975). The bacterial population in field NR latex is always large in any routine collection and many early workers were familiar with microorganisms in latex and in rubber products. A wide variety, mostly strong acid producers are present in field NR latex. They represent species of *Bacillus, Bacterium, Corynebacterium, Escherichia, Micrococcus, Streptococcus, Serratia, Sarcina, Klebsiella, Listeria, Azotobacter, Proteus* and *Pseudomonas* (John, 1977; 1982). The destabilization of fresh and ammoniated NR latex occurs from a build-up of volatile fatty acids (VFA; primarily acetic, formic and propionic acids) due to microbial metabolic activities consuming the rich substrates that constitute the non-rubber phase (Juntarachat et al., 2013). During latex coagulation, the negatively charged protein membranes that surrounds many rubber molecules was neutralized by oxidation reaction due to presence of microorganisms cause the rubber particles repelling to each other and therefore flocculation of latex is occurred (Booten el al., 2011).

Natural rubber latex processing from raw materials until products manufacturing involved intensive chemical usage. At initial state, preservative agent is responsible to arrest microbial growth in field NR latex for certain of period and yet obtain rubber end products of acceptable properties (John, 1976). Preservation of latex is referred to latex that will not undergo coagulation process to form a solid rubber. Ammonia is a commonly used latex preservative agent is added into latex based on the weight of latex depending on the storage time and the condition of the latex (Ong, 1998). Ammonia became the most favourable anti-coagulant agent for NR latex due to its alkalinity and biocide characteristic (Cook, 1960). Although it seems to have many advantages, ammonia is not a suitable compound to be used in prolonging time (Loykulnant et al., 2009). Ammonia can cause detrimental effects to the environment, human health and quality of rubber products (Vivayganathan et al., 2008; Loykulnant et al., 2009). Ammonia could possibly pollute the environmental air by its pungent smell odour and it is easy to evaporate. Chemical residuals from NR latex based products also have been reported by Tinkler et al. (1998). In the study, dithiocarbamates which were being used as accelerators in the latex industry could possibly have carcinogenic effect. Chemical residues in latex based medical devices have been reported to cause allergy reaction to the medical practitioners and patients (Yip and Cacioli, 2002). Study on latex allergenicity by De Jong et al. (2002) due to chemical sensitization activity revealed that chemicals that being used during NR latex glove manufacturing cause chemical sensitization prior to contact and through cross reaction. These chemical could produce substances that were also can trigger the allergen reactions. Extensive usage of chemicals increase the post operating management due to chemical spills or leakage has urged the industry to search for a more environmentally friendly processing that can reduce the dependancy on chemicals process.

Natural rubber industries continually seeks safer and simpler preservation systems and have to discover novel substance than can work without ammonia, be water soluble and be as cheap as tetramethylthiuramdisulphite (TMTD)/zinc oxide (ZnO). In this study the microbial preservative agent as biological alternative to the ammonia-based biocide chemical format was proposed. The simplest approach to this objective would be to search for potential microorganisms that have an advantage in producing antibiotics to suppress VFA producers and excreting surfactant-like substances to increase electrostatic repulsion on rubber particles. Therefore, this work is initiated to culture NR related environmental derived fungi or bacteria (e.g field NR latex, coagulated latex and soil in rubber plantation) and screen for antimicrobial and surfactant activities that might be produced by the isolated fungi and bacteria. This was followed by inoculating the isolates into NR latex and stability of the latex was characterized. The general objective of this study was to search for biological based anti-coagulant agents for NR latex preservation. The specific objectives of this study were:

i. To screening, isolate and characterize microorganisms from environment related with NR latex such as latex serum, coagulated NR latex and soil from rubber plantation area.
ii. To investigate the antimicrobial and surfactant activities from the isolated microbes.
iii. To characterize the properties of treated NR latex with selected microbial isolates.

REFERENCES

Abdel-Megeed, A., Al-Rahma, A. N., Mostafa, A. A. and Baser, K. H. C. (2011). Biochemical characterization of anti-microbial activity of glycolipids produced by *Rhodococcus erythropolis*. *Pakistan Journal of Biology* 43(2): 1323-1334.

Abdel-Daim, A., Hassouna, N., Hafez, M., Ashor, M. S. A. And Aboulwafa, M. M. (2013). Antagonistic Activity of *Lactobacillus* Isolates against *Salmonella typhi* In Vitro [Electronic Version]. *BioMedical Research International.*

Abdullah, A. R. (1995). Environmental pollution in Malaysia: Trends and prospects. *TRAC trends in analytical chemistry* 14(5): 191-198.

Academic Press Dictionary of Science and Technology. *HMA definitions of the terms Antibiotic and Antimicrobial*. http://www.hma.eu/fileadmin/dateien/Veterinary_medicines. Retrieve 26 March 20132.

Adams, T. H., Wieser, J. K. and Yu, J. H. (1998). Asexual sporulation in *Aspergillus nidulans*. *Microbiology and Molecular Biology Reviews* 62(1): 35-54.

Afreen, S., Haque, K. R. and Huda, M. K. (2013). Troubleshooting for the observed problems in processing latex concentrate from natural resource. *IOP Conference Series: Earth and Environmental Science* 16(1): 012007.

Ahimou, F., Jacques, P. and Deleu, M. (2000) Surfactin and iturin a effects on *B. Subtilis* hydrophobicity. *Enzyme Microbiology Technology* 27:749-754.

Almeida, W.C. and Leal Martins, M.L. (2004). Production and properties of an extracellular protease from thermophilic *Bacillus* sp. *Brazilian Journal of Microbiology* 35: 91-96.

Altman, R.F.A. (1947). Natural coagulation of *Hevea* latex. In *Rubber Chemistry and Technology 20(4)*, pp. 1124-1132. American Chemical Society Publisher.

Anand, S.K., Srinivasan, R.A. and Rao, K. (1984). Antimicrobial activity associated with *Bifidobacterium bifidum-I*. *Journal of Culture Dairy Products* 2:6–7.

Anand, S.K., Srinivasan, R.A. and Rao, K. (1985). Antibacterial activity associated with *Bifidobacterium bifidum-II*. *Journal of Culture Dairy Products* 2:21–3.

Anderson, T. H. and Domsch, K. H. (1985). Determination of ecophysiological maintenance carbon requirements of soil microorganisms in a dormant state. *Biology and Fertility of Soils* 1(2): 81-89.

Andrews, J. M. (2001). Determination of minimum inhibitory concentrations. *Journal of Antimicrobial Chemotherapy* 48(Suppl.1): 5-16.

Angrove, S. N. (1964). Preservation of NR latex concentrate; Part I—method of evaluation and evaluation of existing preservative systems. *Transactions of the Institution of the Rubber Industry* Vol. 40: No. 2.

Anyanwu, C. U., Obi, S. K. C. and Okolo, B. N. (2010). Production of surface active glycolipid by *Serratia marcescens* NSK-1 isolated from petroleum contaminated soil. *Our Nature* 8(1): 1-11.

Archer, B. L., Barnard, D., Cockbain, E. G., Cornforth, J. W., Cornforth, R. H. and Popjak, G. (1966). The stereochemistry of rubber biosynthesis. *Proceedings of the Royal Society of London. Series B. Biological Sciences* 163(993): 519-523.

Arora, P. K. and Jain, R. K. (2013). *Arthrobacter nitrophenolicus* sp. *nov*. a new 2-chloro-4-nitrophenol degrading bacterium isolated from contaminated soil. *Biotech*nology 3(1): 29-32.

Artiola, J., Pepper, I. L. and Brusseau, M. L. (2004). *Environmental Monitoring and Characterization*. Oxford: Academic Press.

Asaka, O. and Shoda, M. (1996). Biocontrol of *Rhizoctonia solani* damping-off of tomato with *Bacillus subtilis* RB14. *Applied Environmental Microbiology* 62: 4081–4085.

Ata, S., Davis, E. S., Dupin, D., Armes, S. P. and Wanless, E. J. (2010). Direct observation of pH-induced coalescence of latex-stabilized bubbles using high-speed video imaging. *Langmuir* 26(11): 7865-7874.

Atagana, H. I., Ejechi, B. O. And Ogodu, M. I. (1999). Bacteria associated with degradation of wastes from rubber processing industry. *Environmental Monitoring and Assessment* 59(2): 145-154.

Atlas, R. M. (2004). *Handbook of microbiological media, Volume 1*. Florida: CRC press.

Attanayake, A. P., Karunanayake, L. and Nilmini, A. H. R. *Microbial Activity In Natural Rubber Latex With Currently Existing Preservative Systems.* Paper presented in the International Polymer Science and Technology Symposium, Colombo, Sri Lanka. 2012.

Axelsson, L. and Holck, A. (1995). The genes involved in production of and immunity to sakacin A, a bacteriocin from *Lactobacillus sakei* LB706. *Journal of Bacteriology* 177(8): 2125-2137.

Bahri, M. A., Hoebeke, M., Grammenos, A., Delanaye, L., Vandewalle, N. and Seret, A. (2006). Investigation of SDS, DTAB and CTAB micelle microviscosities by Electron Spin Resonance. Colloids *and Surfaces A: Physicochemical and Engineering Aspects* 290: 206-212.

Banat, I. M., Makkar, R. S. and Cameotra, S. S. (2000). Potential commercial applications of microbial surfactants. *Applied Microbiology and Biotechnology* 53(5): 495-508.

Barnett, H. L. and Hunter, B. B. (1972). Illustrated Genera of imperfect Fungi. *Mycologia* 64(4): 930-932.

Bauer, A. W., Kirby, W. M. M., Sherris, J. C. T. And Turck, M. (1966). Antibiotic susceptibility testing by a standardized single disk method. *American journal of clinical pathology* 45(4): 493.

Benincasa, M. and Accorsini, F. R. (2008). *Pseudomonas Aeruginosa* LBI production as an integrated process using the wastes from sunflower-oil refining as a substrate. *Bioresource Technology* 99: 3843–3849.

Benincasa, M., Abalos, A., Oliveira, I. and Manresa, A. (2004). Chemical structure, surface properties and biological activities of the biosurfactant produced by *Pseudomonas aeruginosa* LBI from soapstock. *Antonie van Leeuwenhoek* 85(1): 1-8.

Benny, L. (1998-2010). Surface tension: physics of continuos matters. *The Lancet.* 358: 135-138.

Bentzen, G. and Demain, A. L. (1990). Studies on gramicidin S-mediated suicide during germination outgrowth of *Bacillus brevis* spores. *Curr. Microbiol*. 20: 165-169.

Berdy, J. (2005). Bioactive microbial metabolites. *The Journal of Antibiotics* 58(1): 1-26.

Berkeley, R. C. W. and Campbelt, R. (1971). Microbial nutrition and the influence of environmental factors on microbial growth and other activities. In *Microorganisms. Function*, *Form and Environment*, pp. 143-168. London: Edward Arnold (Publishers) Limited.

Bhardwaj, G., Cameotra, S.S. and Chopra, H.K. (2013). Biosurfactants from Fungi: A Review. *Journal of Petroleum and Environmental Biotechnology* 4:160.

Bhardwaj, A. and Hartland, S. (1998). Studies on build-up of interfacial film at the crude oil/water interface. *Journal of Dispersion Science and Technology* 19(4): 465-473.

Bhowmick, A. K., Hall, M. M. and Benarey, H. A. (1994). *Rubber Products Manufacturing Technology*. New York, Marcel Dekker, Inc.

Bilski, P., Holt, R. N. and Chignell, C. F. (1997). Premicellar aggregates of Rose Bengal with cationic and zwitterionic surfactants. *Journal of Photochemistry and Photobiology A: Chemistry* 110(1): 67-74.

Blackley, D. C. (1997). Polymer Latices. *Types of Latices (Vol. 2)*. Netherland: Springer.

Blackly, D.C. (1966). High Polymer Latices. *Their Science and Technology Vol. II*. London: MacLaren and Sons Limited.

Blomfield, G. F. (1951). The rubber hydrocarbon in freshly tapped *Hevea* latex. *Rubber Chemistry and Technology* 24(4): 737-749.

Bodour, A. A. and Maier, R. M. (2002). Biosurfactants: types, screening methods, and applications. *Encyclopedia of Environmental Microbiology*.

Bodour, A. A., Drees, K.P. and Raina, M. M. (2003). Distribution of biosurfactant-producing bacteria in undisturbed and contaminated arid southwestern soils. *Applied Environmental Microbiology* 69(6): 3280-3287.

Bohg, A. and Ristow, H. (1987). Tyrocidine-induced modulation of the DNA conformation in *Bacillus brevis*. *European Journal of Biochemistry* 170: 253-258.

Bonev, B., Hooper, J. and Parisot, J. (2008). Principles of assessing bacterial susceptibility to antibiotics using the agar diffusion method. *Journal of Antimicrobial Chemotherapy* 61(6): 1295-1301.

Bonnin, C., Laborie, A. and Paillard, H. (1990). Odor nuisances created by sludge treatment: problems and solutions. *Water Science and Technology* 22(12): 65-74.

Boonsatit, J., Bunkum, L., Nawamawat, K. and Sakdapipanich, J. The study of the bacterial type in fresh natural rubber latex and investigating new preservative for natural rubber latex. In Proceedings of the 34th Congress on Science and Technology of Thailand, Bangkok, Thailand, Oct. 31-Nov. 2. Thailand: 2008.

Booten, K., Yatim, A. H. and Singh, M. (2011). *Natural rubber latex preservation*, US Patent 7989546.

Bortolato, M., Besson, F. and Roux, B. (1997). Inhibition of alkaline phosphatase by surfactin, a natural chelating lipopeptide from Bacillus subtilis. *Biotechnology Letters* 19(5), 433-435.

Borel, M., Kergomard, A. and Renard, M.F. (1982). Degradation of natural rubber by fungi imperfecti. *Agricultural Biology and Chemistry* 46: 877-881.

Breakpoint Tables for Interpretation of MICs and Zone Diameters. 2011. European Committee on Antimicrobial Susceptibility Testing and European Committee on Antimicrobial Susceptibility Testing: Växjö, Sweden.

Broadbent, D. (1966). Antibiotics produced by fungi. *The Botanical Review* 32(3): 219-242.

Brock, T. D. (1974). *Biology of Microorganisms*. New Jersey: Englewood Cliffs.

Broekaert, I., Lee, H. I., Kush, A., Chua, N. H. and Raikhel, N. *Wound-induced accumulation of mRNA containing a hevein sequence in laticifers of rubber tree* (*Hevea brasiliensis*). Proceedings of the National Academy of Sciences 87(19): 7633-7637. 1990.

Brogden, K. A. (2005). Antimicrobial peptides: Pore formers or metabolic inhibitors in bacteria. *Nature Reviews Microbiology* 3(3): 238-250.

Brown, M. J. (1991). Biosurfactants for cosmetic applications. *International Journal of Cosmetic Science* 13(2): 61-64.

Brydson, J. A. *The Chemistry of Rubber*. Applied Science, London. 1978.

Burge, H. A. (1986). Some comments on the aerobiology of fungus spores. *Grana*, 25(2): 143-146.

Burgos-Díaz, C., Piqué i Clusella, N., Manresa Presas, M. Á. M. Á. and Marqués Villavecchia, A. M. (2012). Chapter 9: Advances in the research of new biosurfactants and their potential use in the biomedical and pharmaceutical industry. In D. Muñoz-Torrero, D. Haro and J. Vallès. *Recent Advances in Pharmaceutical Sciences II* (pp. 151-167). Barcelona: Transworld Research Network.

Burlatsky, S. F., Atrazhev, V. V., Dmitriev, D. V., Sultanov, V. I., Timokhina, E. N., Ugolkova, E. A. and Vincitore, A. (2013). Surface tension model for surfactant solutions at the critical micelle concentration. *Journal of Colloid and Interface Science* 393: 151-160.

Cameotra, S. S. and Bollag, J. M. (2003). Biosurfactant-enhanced bioremediation of polycyclic aromatic hydrocarbons. *Critical Reviews in Environmental Science and Technology* 33(2): 111-126.

Canfield, D. E. and Des Marais, D. J. (1993). Biogeochemical cycles of carbon, sulfur, and free oxygen in a microbial mat. *Geochimica et Cosmochimica Acta*, 57(16): 3971-3984.

Cecil, J. and Mitchell, P. *Processing of Natural Rubber*. FAO, Food and Agriculture Organization of the United Nations: Rome, Italy. 2003.

Chaikumpollert, O., Loykulnant, S. and Kongkaew, C. *A Novel Preservative System for Natural Rubber Latex*. Paper presented at the 10^{th} Pacific Polymer Conference, Kobe, Japan. 2007.

Chen, J. L., Lin, W. S. and Tzean, S. S. (2000). A new species of *Lambdasporium* from Taiwan. *Botanical Bulletin of Academia Sinica* 41: 81-84.

Chen, C., Hu, J., Zhang, S., Zhou, P., Zhao, X., Xu, H. and Lu, J. R. (2012). Molecular mechanisms of antibacterial and antitumor actions of designed surfactant-like peptides. *Biomaterials* 33(2): 592-603.

Chen, H., Tian, F., Li, S., Xie, Y., Zhang, H. and Chen, W. (2012). Cloning and heterologous expression of a bacteriocin sakacin P from *Lactobacillus sakei* in *Escherichia coli*. *Applied Microbiology and Biotechnology* 94(4): 1061-1068.

Chen, S. F. and Ng, C. S. (1984). The natural higher fatty acid soaps in natural rubber latex and their effect on the mechanical stability of the latex. *Rubber Chemistry and Technology* 57(2): 243-253.

Cheng, M. J., Lee, K. H., Tsai, I. L., and Chen, I. S. (2005). Two new sesquiterpenoids and anti-HIV principles from the root bark of *Zanthoxylum ailanthoides. Bioorganic and Medicinal Chemistry* 13(21): 5915-5920.

Chikindas, M. L., García-Garcerá, M. J., Driessen, A. J., Ledeboer, A. M., Nissen-Meyer, J., Nes, I. F. and Venema, G. (1993). Pediocin PA-1, a bacteriocin from *Pediococcus acidilactici* PAC1.0, forms hydrophilic pores in the cytoplasmic membrane of target cells. *Applied and Environmental Microbiology* 59(11): 3577-3584.

Chow, K. S., Mat-Isa, M. N., Bahari, A., Ghazali, A. K., Alias, H., Zainuddin, Z. M. and Wan, K. L. (2012). Metabolic routes affecting rubber biosynthesis in *Hevea brasiliensis* latex. *Journal of Experimental Botany* 63(5): 1863-1871.

Christian, P., Schmitz, P., Meurer, K., Daniel, D., Bamberg, V., Lohmann, S., Castro França, S.D., Groth, I., Schlegel, B., Möllmann, M. and Gollmick, F. (2002). New and bioactive compounds from *Streptomyces* strains residing in the wood of *Celastraceae. PLANTA* 216(1): 162-167.

Christofi, N. and Ivshina, I. B. (2002). Microbial surfactants and their use in soil remediation. *Book: Bioremediation of aquatic and terrestrial ecosystems*. New York: Wiley Publication.

Christofi, N. And Ivshina, I. B. (2002). Microbial surfactants and their use in field studies of soil remediation. *Journal of Applied Microbiology* 93(6): 915-929.

Cloete, T. E. (2003). Resistance mechanisms of bacteria to antimicrobial compounds. *International Biodeterioration and Biodegradation* 51(4): 277-282.

Crous, P. W., Phillips, A. J. and Wingfield, M. J. (1992). Effects of cultural conditions on vesicle and conidium morphology in species of *Cylindrocladium* and *Cylindrocladiella*. *Mycologia* 84(4): 497-504.

Crous, P. W. (2002). *Taxonomy and pathology of Cylindrocladium (Calonectria) and allied genera*. US: American Phytopathological Society (APS Press).

Crous, P. W., Groenewald, J. Z., Risède, J. M., Simoneau, P. and Hywel-Jones, N. L. (2004). *Calonectria* species and their *Cylindrocladium* anamorphs: species with sphaeropedunculate vesicles. *Studies in Mycology* 50(2): 415-430.

Crosman, J. T., Pinchuk, R. J. and Cooper, D. G. (2002). Enhanced biosurfactant production by *Corynebacterium alkanolyticum* ATCC 21511 using self-cycling fermentation. *Journal of the American Oil Chemists' Society* 79(5): 467-472.

Cronin, D., MoenneLoccoz, Y., Fenton, A., Dunne, C., Dowling, D.N. and Ogara, F. (1997). Role of 2,4-diacetylphloroglucinol in the interactions of the biocontrol pseudomonad strain F113 with the potato cyst nematode *Globodera rostochiensis*. *Applied Environmental Microbiology* 63: 1357–1361.

Cook, A.S. (1960). The short-term preservation of natural latex. *Journal of the Rubber Research* 16(2): 65-86.

Corbet, A. S. (1930). The natural coagulation of *Hevea* latex. *Rubber Chemistry and Technology* 3(2): 254-263.

Cortés-Sánchez, A. D. J., Hernández-Sánchez, H. and Jaramillo-Flores, M. E. (2012). Biological activity of glycolipids produced by microorganisms: New trends and possible therapeutic alternatives. *Microbiological Research* 168(1): 22-32.

Daruliza, K. M., Lam, K. L., Yang, K. L., Priscilla, J. T., Sunderasan, E. and Ong, M. T. (2011). Anti-fungal effect of *Hevea brasiliensis* latex C-serum on *Aspergillus niger*. *European Eview for Medical and Pharmacological Sciences* 15(9): 10-27.

Das, N. and Chandran, P. (2010). Microbial degradation of petroleum hydrocarbon contaminants: An overview. *Biotechnology Research International* 2011. India: Hindawi Publishing Corporation.

De Jong, W. H., Van Och, F. M., Jager, C. F. D. H., Spiekstra, S. W., Slob, W., Vandebriel, R. J. and Van Loveren, H. (2002). Ranking of allergenic potency of rubber chemicals in a modified local lymph node assay. *Toxicological Sciences* 66(2): 226-232.

Desai, J. D. and Banat, I. M. (1997). Microbial production of surfactants and their commercial potential. *Microbiology and Molecular Biology Reviews* 61(1): 47-64.

Diener, U.L. and Davis, N.D. Biology of *Aspergillus flavus* and *A. Parasiticus*, In Aflatoxin in Maize, Proceedings of the Workshop, El Batan, Mexico, April 7-11. Mexico, 1986.

Dimitrova, T.D., Leal-Calderon, F., Gurkov, T.D., and Campbell, B. (2004). Surface forces in model oil-in-water emulsions stabilized by proteins. *Advances in Colloidal and Interface Science* 108(109): 73-86.

Eaman, M., Berquand, A., Dufrene, Y. F., Paquot, M., Dufour, S. and Deleu, M. (2006). Penetration of surfactin into phospholipid monolayers: nanoscale interfacial organization. *Langmuir* 22: 11337-11345.

Eddouaouda, K. Mnif, S. Badis, A. Younes, S. B. Cherif, S. Ferhat, S. and Sayadi, S. (2012). Characterization of a novel biosurfactant produced by *Staphylococcus* sp. strain 1E with potential application on hydrocarbon bioremediation. *Journal of Basic Microbiology* 52(4): 408-418.

Eyéghé-Bickong, H. A. (2011). *Role of surfactin from Bacillus subtilis in protection against antimicrobial peptides produced by Bacillus species*. PhD Thesis, University of Stellenbosch.

Falatko, D. M. and Novak, J. T. (1992). Effects of biologically produced surfactants on the mobility and biodegradation of petroleum hydrocarbons. *Water Environment Research*: 163-169.

Faleschini, G., Hacker, V., Muhr, M., Kordesch, K. and Aronsson, R.R. Ammonia for high density hydrogen storage. Paper presented in the Fuel Cell Seminar, Portland: Oregon. Nov 2000.

Ferragut, V. and Chiralt, A. (1996). Microstructure of oil-in-water low-fat emulsions containing skim milk powder and locust bean gum. *LWT-Food Science and Technology* 29(7): 648-653.

Florence, A. T., Attwood, D. and Attwood, D. (2011). *Physicochemical principles of pharmacy*. Pharmaceutical Press.

Frangou-Lazaridis, M. and Seddon, B. (1985). Effect of gramicidin S on the transcription system of the producer *Bacillus brevis* Nagano. *Journal of Genetic Microbiology* 131: 437-449.

Franzetti, A., Gandolfi, I., Bestetti, G., Smyth, T. J. and Banat, I. M. (2010). Production and applications of trehalose lipid biosurfactants. *European Journal of Lipid Science and Technology* 112(6): 617-627.

Freeman, R. (1957). Microgel in latex and sheet rubber. *Rubber Chemistry and Technology* 30(1): 242-249.

Fremaux, C. and Klaenhammer, T. R. (1994). Helveticin J, A Large Heat-Labile Bacteriocin From Lactobacillus Helveticus. In *Bacteriocins of Lactic Acid Bacteria*, pp. 397-418. US: Springer.

Frezieres, R. G. and Walsh, T. L. (2000). Acceptability evaluation of natural rubber latex, a polyurethane, and a new non-latex condom. *Contraception* 61(6): 369-377.

Gaining traction: The rubber industry is on the move. Oxford Business Group. Retrieve at http://www.oxfordbusinessgroup.com/news/gaining-traction-rubber-industry-move. 2012.

Galli, V., García, A., Saavedra, L. and Barbas, C. (2003). Capillary electrophoresis for short-chain organic acids and inorganic anions in different samples. *Electrophoresis* 24(12-13): 1951-1981.

Gandhimathi, R., Seghal Kiran, G., Hema, T.A., Selvin, J., Rajeetha Raviji, T. and Shanmughapriya, S. (2009). Production and characterization of lipopeptide biosurfactant by a sponge-associated marine *Actinomycetes Nocardiopsis Alba* MSA10. *Bioprocess and Biosystems Engineering* 32(6): 825-835.

Garland, J. L. and Mills, A. L. (1991). Classification and characterization of heterotrophic microbial communities on the basis of patterns of community level sole-carbon-source utilization. *Applied and Environmental Microbiology* 57(8): 2351-2359.

Gavrilescu, M. and Chisti, Y. (2005). Biotechnology- a sustainable alternative for chemical industry. *Biotechnology Advances* 23(7): 471-499.

Gazeley, K.F., Gorton, A.D.T. and Pendle, T.D. (1988). Latex concentrates: properties and composition. In *Natural Rubber Science and Technology*, ed. A.H. Roberts, pp. 63-98. Oxford: Oxford University Press.

Gazis, R. and Chaverri, P. (2010). Diversity of fungal endophytes in leaves and stems of wild rubber trees *Hevea brasiliensis* in Peru. *Fungal Ecology* 3(3), 240-254.

Geris, R. and Simpson, T. J. (2009). Meroterpenoids produced by fungi. *Natural Product Reports* 26(8): 1063-1094.

Gidrol, X., Chrestin, H., Tan, H. L. and Kush, A. (1994). Hevein, a lectin-like protein from *Hevea brasiliensis* (rubber tree) is involved in the coagulation of latex. *Journal of Biological Chemistry* 269(12): 9278-9283.

Glove industry still going strong in Malaysia; Rubber Journal of Asia: Selangor, Malaysia, 2011.

Gong, Y., Liu, G., Peng, W., Su, X. and Chen, J. (2013). Immobilization of the proteins in the natural rubber with dialdehyde sodium alginate. *Carbohydrate Polymers* 98(2): 1360-1365.

Gouffi, K., Pica, N., Pichereau, V. and Blanco, C. (1999). Disaccharides as a new class of nonaccumulated osmoprotectants for *Sinorhizobium meliloti*. *Applied and Environmental Microbiology* 65(4): 1491-1500.

Green, J. R. *Protein Substances in Latex*. Proceedings of the Royal Society of London. London, 1886.

Guirard, B. M. (1958). Microbial nutrition. *Annual Reviews in Microbiology* 12(1): 247-278.

Gurkov, T.D., Dimitrova, T.D., Marinova, K.G., Bilke-Crause, C., Gerber, C., Ivanov, I.B. (2005). Ionic surfactants on fluid interfaces: determination of the adsorption; role of the salt and the type of the hydrophobic phase. *Colloids and Surfaces A: Physicochem. Eng. Aspects* 261: 29–38.

Haigh, S. D. (1996). A review of the interaction of surfactants with organic contaminants in soil. *Science of the Total Environment* 185(1): 161-170.

Hartmann, S., Wolf, G. And Hammes, W. P. (1995). Reduction of Nitrite by *Staphylococcus carnosus* and *Staphylococcus piscifermentans*. *Systematic and Applied Microbiology* 18(3): 323-328.

Hamoen, L. W., Venema, G. and Kuipers, O. P. (2003). Controlling competence in *Bacillus subtilis*: shared use of regulators. *Microbiology* 149(1): 9-17.

Hasma H. and Subramaniam A. (1986). Composition of lipids in latex of *Hevea brasiliensis* clone RRIM 501. *Journal of Rubber Research* 1: 30-40.

Hazalin, N.A., Kalavathy, R., Lim, S.M., Wahab, I.A., Anthony, L. J. C., and Abdul Majeed, A.B. (2009). Cytotoxic and antibacterial activities of endophytic fungi isolated from plants at The National Park, Pahang, Malaysia [Electronic version]. *BMC Complementary and Alternative Medicine* 9(46).

Herman, D. C., Zhang, Y. and Miller, R. M. (1997). Rhamnolipid (biosurfactant) effects on cell aggregation and biodegradation of residual hexadecane under saturated flow conditions. *Applied and Environmental Microbiology* 63(9): 3622-3627.

Hewald, S., Josephs, K. and Bölker, M. (2005). Genetic analysis of biosurfactant production in *Ustilago maydis*. *Applied and Environmental Microbiology* 71(6): 3033-3040.

Hildebrand, P. D., Braun, P. G., McRae, K. B. and Lu, X. (1998). Role of the biosurfactant viscosin in broccoli head rot caused by a pectolytic strain of *Pseudomonas fluorescens*. *Canadian Journal of Plant Pathology* 20(3): 296-303.

Hirano, S. (1986). Chitin and chitosan. *Ullmann's Encyclopedia of Industrial Chemistry*. John Wiley & Sons, Inc. 2002.

Ho, C. C., Kondo, T., Muramatsu, N. and Ohshima, H. (1996). Surface structure of natural rubber latex particles from electrophoretic mobility data. *Journal of Colloid and interface Science* 178(2): 442-445.

Holt, J. G. (1994). *Bergey's Manual of Determinative Bacteriology*. Baltimore: Williams & Wilkins.

Holler, U., Wright, A.D., Matthee, G.F., Konig, G.M., Draeger, S., Aust, H.J. and Schulz, B. (2000). Fungi from marine sponges: diversity, biological activity and secondary metabolites. *Mycological Resources* 104: 1354-1365.

Hong, S. B., Kim, D. H., Lee, M., Baek, S. Y., Kwon, S. W. and Samson, R. A. (2011). Taxonomy of *Eurotium* species isolated from Meju. *The Journal of Microbiology* 49(4): 669-674.

Horn, W.S., Simmonds, M.S.J., Schwartz, R.E. and Blaney, W.M. (1995). Phomopsichalasin, a novel antimicrobial agent from an endophytic *Phomopsis* sp. *Tetrahedron* 51:3969.

Hoşgor Limoncu, M., Ermertcan, Ş., Eraç, B. and Taşlı, H. (2011). An investigation of the antimicrobial impact of drug combinations against *Mycobacterium tuberculosis* strains. *Turkey Journal of Medical Science* 41: 719–24.

Hoven, V. P., Rattanakarun, K. and Tanaka, Y. (2004). Reduction of offensive odor from natural rubber by odor-reducing substances. *Journal of Applied Polymer Science* 92(4): 2253-2260.

Humber, R. A. (1997). *Fungi: Identification*. In Manual of Techniques in Insect Pathology. Academic Press, San Diego, USA: 153-186.

Hutter, B., Schaab, C., Albrecht, S., Borgmann, M., Brunner, N. A., Freiberg, C. and Loferer, H. (2004). Prediction of mechanisms of action of antibacterial compounds by gene expression profiling. *Antimicrobial Agents and Chemotherapy* 48(8): 2838-2844.

Imai, Y., Adachi, Y., Kimura, T., Nakano, C., Shimizu, T., Shi, M. and Ikehara, S. (2012). An autopsy case of pulmonary fissure induced by zygomycosis. *International Journal of General Medicine* 6: 575-579.

Intapun, J., Sainte-Beuve, J., Bonfils, F., Tanrattanakul, V., Dubreucq, E., and Vaysse, L. (2009). Characterisation of Natural Rubber Cup Coagula Maturation Conditions and Consequences on Dry Rubber Properties. *Journal of Rubber Research* 12(4): 171-184.

International Organization for Standardization. (1992). *Rubber latex, natural, concentrate – Determination of volatile fatty acid number*. ISO 506:1992(E).

International Organization for Standardization. (2011). *Rubber latex – Determination of viscosity*. ISO 1652 – 2011(E).

James R, Lazdunski C, Pattus F. (1991). Bacteriocins, Microcins and Lantibiotics. In *Evolution and Ecology of Bacteriocins* 135(65), pp. 519. New York: Springer-Verlag.

Jansen, N. B., Flickinger, M. C. and Tsao, G. T. (1984). Production of 2, 3-butanediol from D-xylose by *Klebsiella oxytoca* ATCC 8724. *Biotechnology and bioengineering* 26(4): 362-369.

Jarvis, B.B., Sorenson, W.G., Hintikka, E.L., Nikulin, M., Zhou, Y., Jiang, J., Wang, S., Hinkley, S., Etzel, R.A. and Dearborn, D. (1998). Study of toxin production by isolates of *Stachybotrys chartarum* and *Memnoniella echinata* isolated during a study of pulmonary hemosiderosis in infants. *Applied Environmental Microbiol*ogy 64: 3620-3625.

Jayachandran, K. and Chandrasekaran, M. (1998). Biological coagulation of skim latex using *Acinetobacter* sp. isolated from natural rubber latex centrifugation effluent. *Biotechnology Letters* 20(2): 161-164.

Jendrossek, D., Tomasi, G. and Kroppenstedt, R. M. (1997). Bacterial degradation of natural rubber: a privilege of actinomycetes. *FEMS Microbiology Letters* 150(2): 179-188.

Jensen, H. L. (1965). Nonsymbiotic nitrogen fixation. In *Soil nitrogen*, pp. 436-480. US: Springer.

Jha, M. K., Kumar, V. and Singh, R. J. (2001). Review of hydrometallurgical recovery of zinc from industrial wastes. *Resources, Conservation and Recycling* 33(1): 1-22.

John, C. K. (1968). A medium for isolating and cultivation of *Hevea* Latex Bacteria. *Bulletin of Rubber Research Institute of Malaysia* 20(4): 236.

John, C. K. and Pillai, N. M. (1971). Improvements to assisted biological coagulation of Hevea latex. *Journal of Rubber Research* 23(2): 138-146.

John, C. K. and Verstraete, W. *Microbial Deterioration and Preservation of Hevea Latex.* Paper presented at the meeting of the Fourth International Biodeteroration Symposium, Berlin. 1978.

John, C.K. 1977. *Microbiological Studies On Hevea Latex With Particular Reference To Its Keeping Quality and Coagulation*, PhD Thesis, University of Gent, Belgium.

John, C.K. *A Composite Preservation System for Hevea Latex*. Paper presented in the International Rubber Conference, Kuala Lumpur. 1976.

John, C.K. and Newsam, A. (1969). Continuous coagulation of *Hevea* latex. *Planters' Bulletin* (105): 289-293.

John, C.K. *Microbiology of Hevea Latex- Its Deterioration and Preservation*. Paper presented at the 5th Malaysian Microbiology Symposium, Kuala Lumpur. October 1982.

John, C.K., Wong, N.P., Chin, H.C., Latiff, A. and Lim, H.S. *Recent Development in Natural Rubber Latex Preservation.* Paper presented at the Rubber Research Institute of Malaysia Rubber Growers' Conference, Kuala Lumpur. 1986.

John, C.K., Wong, N.P., Chin, H.C., Rama Rao, P.S. and Abdul Latiff. *Further Development in Hevea Latex Preservation.* Paper presented at the International Rubber Conference, Kuala Lumpur.1985.

Jönsson, B., Kronberg, B. and Lindman, B. (2003). *Surfactants and polymers in aqueous solution* (Vol. 2). Chichester: John Wiley & Sons.

Juntarachat, N., Bouvier, N., Lepoutre, J. P., Roland, A., Sainte-Beuve, J., Granet, F. and Chalier, P. (2013). Identification by GC-O and GC-MS of new odorous compounds in natural rubber. *Journal of Applied Polymer Science* 130(3): 1863-1872.

Kakinuma, A., Hori, M., Isono, M., Tamura, G. and Arima, K. (1969). Determination of amino acid sequence in surfactin, a crystalline peptidelipid surfactant produced by *Bacillus subtilis*. *Agricultural And Biological Chemistry* 33(6): 971-972.

Kalchayanand, N., Hanlin, M. B. and Ray, B. (1992). Sublethal injury makes Gram-negative and resistant Gram-positive bacteria sensitive to the bacteriocins, pediocin AcH and nisin. *Letters in Applied Microbiology* 15(6): 239-243.

Kang, K.H., Shin, H.J., Park, Y.H. and Lee, T.S. (1989). Studies on the antibacterial substances produced by lactic acid bacteria: purification and some properties of antibacterial substance "Bifilong" produced by *B. longum*. *Korean Dairy Science* 1:204–216.

Karanth, N. G. K., Deo, P. G. and Veenanadig, N. K. (1999). Microbial production of biosurfactants and their importance. *Current Science* 77(1): 116-126.

Karunanayake, L. and Perera, G. M. (2006). Effect of magnesium and phosphate ions on the stability of concentrated natural rubber latex and the properties of natural rubber latex–dipped products. *Journal of Applied Polymer Science* 99(6): 3120-3124.

Kasinathan, S., Nadarajah, M. and Tirimanne, A. S. L. (1971). A study of the free amino acids in the latex of natural rubber. *RRIC Bulletin* 6: 29.

Kaul, S., Gupta, S., Ahmed, M. and Dhar, M. K. (2012). Endophytic fungi from medicinal plants: A treasure hunt for bioactive metabolites. *Phytochemistry Reviews*: 1-19.

Kawahara, A., Kakubo, T., Suzuki, M. and Tanaka, Y. (1999). Thermal properties and crystallization behavior of highly deproteinized natural rubber. *Rubber Chemistry and Technology* 72(1): 174-180.

Kawai, M., Yamamura, H., Tanaka, R., Umemoto, H., Ohmizo, C., Higuchi, S. and Katsu, T. (2005). Proline residue-modified polycationic analogs of gramicidin S with high antibacterial activity against both Gram-positive and Gram-negative bacteria and low hemolytic activity. *Journal of Peptide Resource* 65: 98-104.

Kaya, O., Akçam, F. and Yaylı, G. (2012). Investigation of the in vitro activities of various antibiotics against *Brucella melitensis* strains. *Turkey Journal of Medical Science* 42: 145–8.

Kearns, D. B. and Losick, R. (2003).Swarming motility in undomesticated *Bacillus subtilis*. *Molecules Microbiology* 49: 581-590.

Keshk, S. M. A. S. and Sameshima, K. (2005). Evaluation of different carbon sources for bacterial cellulose production. *African Journal of Biotechnology* 4(6): 478-482.

Kim, K. (1998). Suppression of inflammatory responses by surfactin, a selective inhibitor of platelet cytosolic phospholipase A2. *Biochemical Pharmacology* 55: 975-985.

Kim, S., Shin, D. S., Lee, T. and Oh, K. B. (2004). Periconicins, two new fusicoccane diterpenes produced by an endophytic fungus *Periconia* sp. with antibacterial activity. *Journal of Natural Products* 67(3): 448-450.

Kinsinger, R., Shirk, M. C. and Fall, R. (2003). Rapid surface motilitycin *Bacillus subtilis* is dependent on extracellular surfactin and potassium ion. *Journal of Bacteriology* 185: 5627-5631.

Kjer, J., Wray, V., Edrada-Ebel, R., Ebel, R., Pretsch, A., Lin, W. and Proksch, P. (2009). Xanalteric acids I and II and related phenolic compounds from an endophytic *Alternaria* sp. isolated from the mangrove plant *Sonneratia alba*. *Journal of Nature Products* 72(11):2053–2057.

Klaenhammer TR. (1988). Bacteriocins of lactic acid bacteria. *Biochemistry* 70:337–49.

Klingler, J.M., Stowe, R.P., Obenhuber, D.C., Groves, T.O., Mishra, S.K. and Pierson, D.L. (1992). Evaluation of the Biolog automated microbial identification system. *Applied Environmental Microbiology* 58: 2089-2092.

Kokal, S. and Al-Juraid, J. Quantification of various factors affecting emulsion stability: watercut, temperature, shear, asphaltene content, demulsifier dosage and mixing different crudes. Paper presented in the SPE Annual Technical Conference and Exhibition. Houston, Texas, Oct. 1999.

Kondejewski, L. H., Farmer, S. W., Wishart, D. S., Hancock, R. E. and Hodges, R. S. (1996). Gramicidin S is active against both gram positive and gram-negative bacteria. *International Journal of Peptide Protein Resource* 47: 460– 466.

Kong, M., Chen, X. G., Xing, K. and Park, H. J. (2010). Antimicrobial properties of chitosan and mode of action: A state of the art review. *International Journal of Food Microbiology* 144(1): 51-63.

Kongkaew, C., Loykulnant, S., Chaikumpollert, O. and Suchivaa, K. (2009). Study of N-(2-hydroxy) propyl-3-trimethylammonium chitosan chloride (HTACH) as preservatives for field natural rubber latex: effects of molecular weight and degree of substitution of HTACH. http://www2.mtec.or.th/th/seminar/Msativ/pdf/P13.pdf. Retrieved 15 April 2012.

Kroschwitz, J. I. (1990). *Concise Encyclopedia of Polymer Science and Engineering*. Hoboken, NJ: Wiley InterScience of John Wiley & Sons, Inc.

Kumar, S. and Kaushik, N. (2012). Metabolites of endophytic fungi as novel source of biofungicide: A review. *Phytochemistry Reviews*: 1-16.

Kumara, P. H., Prasad, A. K. D. and Rohanadeepa, V. C. (2012). Blending of high VFA latex concentrate with low VFA latex concentrate. *Journal of Rubber Research* 15(2): 96-110.

Kuo, Y.C., Eum, W.J., Shiao, M.S., Chen, C.F. and Lin, C.Y. (1996). Cordyceps sinensis as an immunomodulatory agent. *American Journal of Chinese Medicine* 24: 111-125.

Kuriakose, B. (1992). Primary processing. *Developments in Crop Science* 23: 370-370.

Kusari, S., Zuhlke, S., Kosuth, J., Cellarova, E. and Spiteller, M. (2009). Light-independent metabolomics of endophytic *Thielavia subthermophila* provides insight into microbial hypericin biosynthesis. *Journal of Nature Products* 72(10):1825–1835.

Langner, R. R. (1966). *Latex Stabilization and Preservation*. U.S. Patent 3280065.

Larone, D. H. and Howard, D. H. (1996). Medically Important Fungi: A Guide to Identification (3rd edn). *Trends in Microbiology* 4(6): 252.

Larsen, A. G., Vogensen, F. K. and Josephsen, J. (1993). Antimicrobial activity of lactic acid bacteria isolated from sour doughs: Purification and characterization of bavaricin A, a bacteriocin produced by *Lactobacillus bavaricus* MI401. *Journal of Applied Microbiology* 75(2): 113-122.

Latgé, J. P. (1999). *Aspergillus fumigatus* and aspergillosis. *Clinical Microbiology Reviews*,12(2): 310-350.

Lee, S.Y. and Kang, T.S. (1996). Production conditions and characterization of the exo-polymer produced by submerged cultivation of *Ganoderma lucidum* mycelium. *Korean Journal of Applied Microbiology and Biotechnology* 24: 111-118.

Lefebvre, A.H. (1989). *Atomization and Spray*. Washington: Hemisphere Publishing Corporation

Li, Y., Song, Y. C., Liu, J. Y., Ma, Y. M. and Tan, R. X. (2005). Anti-Helicobacter pylori substances from endophytic fungal cultures. *World Journal of Microbiology and Biotechnology* 21(4): 553-558.

Ligon, J.M., Hill, D.S., Hammer, P.E., Torkewitz, N.R., Hofmann, D., Kempf, H.J. and van Pee, K.H. (2000). Natural products with antifungal activity from *Pseudomonas* biocontrol bacteria. *Pest Management Science* 56:688–695.

Ling, W. Y. L., Lu, G. and Ng, T. W. (2011). Increased stability and size of a bubble on a superhydrophobic surface. *Langmuir* 27(7): 3233-3237.

Liu, X., Huang, W. and Wang, E. (2005). An electrochimical study on the interaction of surfactin with a supported bilayer lipid on a glassy carbon electrode. *Journal of Electroanalytical Chemistry* 577: 349-354.

Liu, Z., Xu, D., Liang, J., Shen, J., Zhang, S. and Qian, Y. (2005). Growth of Cu2S ultrathin nanowires in a binary surfactant solvent. *The Journal of Physical Chemistry B* 109(21): 10699-10704.

Liu, X., Dong, M., Chen, X., Jiang, M., Lv, X. and Yan, G. (2007). Antioxidant activity and phenolics of an endophytic *Xylaria* sp. from Ginkgo biloba. *Food Chemistry* 105:554–584.

Lowe, J. S. *The substrate for VFA formation in natural rubber latex*. Paper presented at the Natural Rubber Research Conference, Kuala Lumpur. 1961.

Lowe, C, Willey B., O'Shaughnessy, A., Lee, W., Lum, M., and Pike, K. (2012). Outbreak of extended-spectrum β-lactamase–producing *Klebsiella oxytoca* infections associated with contaminated handwashing sinks. *Emerging Infectous Diseases* 18(8); 1242.

Loykulnant, S., Chaikumpollert, O. and Kongkaew, C. (2009). Innovation of preservative system for fresh natural rubber latex. http://www.researchgate.net/publication/39026389_Innovation_of_Preservative_System_for_Fresh_Natural_Rubber_Latex. Retrieved 25 July 2012.

Loykulnant, S., Kongkaew, C., Chaikumpollert, O., Sanguanthammarong, P., Na Ubol, P. and Suchiva, K. (2011). Study of chitosan and its derivatives as preservatives for field natural rubber. *Journal of Applied Polymer Science* 123(2): 913-921.

Lupis, S. G., Galles, K. J., Ham, J. M., Westover, E., Stratton, J. J., Wagner, J. and Davis, J. G. Best Management Practices for Reducing Ammonia Emissions: Beef Cattle Nutrition. *Colorado State University Extension factsheet*, 2012.

Magan, N. (2007). Fungi in Extreme Environments. *Environmental and Microbial Relationships: Environmental and Microbial Relationships. IV*, 4: 85.

Mahat, M.S., Wong, N.P., Chin, H.C. and Majid, A.L. (1991). Preservation in polybags and latex concentrate production. *Journal of Rubber Research* 6(2):115-126.

Maier, R. M. and Soberon-Chavez, G. (2000). *Pseudomonas aeruginosa* rhamnolipids: biosynthesis and potential applications. *Applied Microbiology and Biotechnology* 54(5): 625-633.

Makkar, R. S. and Cameotra, S. S. (1997). Biosurfactant production by a thermophilic Bacillus subtilis strain. *Journal of Industrial Microbiology and Biotechnology* 18(1): 37-42.

Manroshan, S., Amir Hashim, M.Y., and Booten, K. (2007). The effect of hydrophobically modified inulin on the properties of natural rubber latex concentrates. *Journal of Rubber Research* 13(3): 156-165.

Manroshan, S., Amir-Hashim, M.Y. and Booten, K. *The Effect of A Biobased Surfactant On The Properties Of Natural Rubber Latex Concentrates.* Paper presented at the Latex and Synthetic Polymer Dispersion Conference, Kuala Lumpur. 2008.

Maraki, S., Sarchianaki, E. and Barbagadakis, S. (2012). *Myroides odoratimimus* soft tissue infection in an immunocompetent child following a pig bite: case report and literature review. *The Brazilian Journal of Infectious Diseases* 16(4): 390-392.

Margaret, A. R., and John, E.W. (2002). Bacteriocins: evolution, ecology, and application. *Annual Review of Microbiology* 56: 117–37.

Martinez, F. A. C., Balciunas, E. M., Converti, A., Cotter, P. D. and de Souza Oliveira, R. P. (2013). Bacteriocin production by *Bifidobacterium* spp. A review. *Biotechnology Advances* 31(4): 482-488.

Mattei, M., Kontogeorgis, G. M. and Gani, R. (2013). Modeling of the critical micelle concentration (CMC) of nonionic surfactants with an extended group-contribution method. *Industrial and Engineering Chemistry Research* 52(34): 12236-12246.

Matuschek, E., Brown, D. F. J. And Kahlmeter, G. (2014). Development of the EUCAST disk diffusion antimicrobial susceptibility testing method and its implementation in routine microbiology laboratories. *Clinical Microbiology and Infection* 20(4): 255-266.

McClements, D. J. and Dungan, S. R. (1993). Factors that affect the rate of oil exchange between oil-in-water emulsion droplets stabilized by a nonionic surfactant: droplet size, surfactant concentration, and ionic strength. *The Journal of Physical Chemistry* 97(28): 7304-7308.

McCrory, D. F. and Hobbs, P. J. (2001). Additives to reduce ammonia and odor emissions from livestock wastes. *Journal of Environmental Quality* 30(2): 345-355.

McDonough, W., Braungart, M., Anastas, P. T. and Zimmerman, J. B. (2003). Peer reviewed: Applying the principles of green engineering to cradle-to-cradle design. *Environmental Science and Technology* 37(23): 434A-441A.

McGavack, J. (1959). The preservation and concentration of *Hevea* latex. *Rubber Chemistry and Technology* 32(5): 1660-1674.

Mendonca, A. F., Amoroso, T. L. and Knabel, S. J. (1994). Destruction of Gram-negative food-borne pathogens by high pH involves disruption of the cytoplasmic membrane. *Applied and Environmental Microbiology* 60(11): 4009-4014.

Mercad´e, M. E., Manresa, M. A. and Robert, M. (1993). Olive oil mill effluent (OOME). New substrate for biosurfactant production. *Bioresources Technology* 43 (1): 1–6.

Milner, J. L., Silo-Suh, L., Lee, J. C., He, H., Clardy, J. and Handelsman, J. (1996). Production of kanosamine by *Bacillus cereus* UW85. *Applied and Environmental Microbiology* 62(8): 3061-3065.

Minnan, L., Jinli, H., Xiaobin, W., Huijuan, X., Jinzao, C., Chuannan, L. and Liangshu, X. (2005). Isolation and characterization of a high H2-producing strain *Klebsiella oxytoca* HP1 from a hot spring. *Research in Microbiology* 156(1): 76-81.

Moir, G. F. J. (1959). Ultracentrifugation and staining of *Hevea* latex. *Nature* 184: 1626-1628.

Morikawa, M., Daido, H., Takao, T., Murata, S., Shimonishi, Y. and Imanaka, T. (1993). A new lipopeptide biosurfactant produced by *Arthrobacter* sp. strain MIS38. *Journal of Bacteriology* 175(20): 6459-6466.

Morones, J. R., Elechiguerra, J. L., Camacho, A., Holt, K., Kouri, J. B., Ramírez, J. T. and Yacaman, M. J. (2005). The bactericidal effect of silver nanoparticles. *Nanotechnology* 16(10): 2346.

Mørtvedt, C. I., Nissen-Meyer, J., Sletten, K. and Nes, I. F. (1991). Purification and amino acid sequence of lactocin S, a bacteriocin produced by *Lactobacillus sake* L45. *Applied and Environmental Microbiology* 57(6): 1829-1834.

Mulligan, C. N., Yong, R. N. and Gibbs, B. F. (2001). Surfactant-enhanced remediation of contaminated soil: A review. *Engineering Geology* 60(1): 371-380.

Mulligan, C. N. (2005). Environmental applications for biosurfactants. *Environmental Pollution* 133(2): 183-198.

Muriana, P. M. and Klaenhammer, T. R. (1991). Purification and partial characterization of lactacin F, a bacteriocin produced by *Lactobacillus acidophilus* LI088. *Applied and Environmental Microbiology* 57(1): 114-121.

Muthumary, J. and Nithya, K. (2011). Bioactive Metabolite Produced by Phomopsis sp., an Endophytic Fungus in Allamanda cathartica Linn. *Recent Research in Science and Technology* 3(3).

Nakano, M. M. and Zuber, P. (1998). Anaerobic Growth of a Strict Aerobe (*Bacillus Subtilis*). *Annual Review of Microbiology* 52: 165–90.

Nakayama, T., Homma, Y., Hashidoko, Y., Mizutani, J., and Tahara, S. (1999). Possible role of xanthobaccins produced by *Stenotrophomonas* sp. strain SB-K88 in suppression of sugar beet damping-off disease. *Applied and Environmental Microbiology* 65(10): 4334-4339.

National Committee for Clinical Laboratory Standards. 2000. Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically : Wayne, Pennsylvania.

Ni, Z., Li, G. and Zhao, P. (2008). Antimicrobial components of the endophytic fungal strain *Chaetomium globosum* Ly50' from *Maytenus hookeri*. *Natural Product Research and Development* 20(1): 33.

Nielsen, K. F., Gräfenhan, T., Zafari, D. and Thrane, U. (2005). Trichothecene production by *Trichoderma brevicompactum*. *Journal of Agricultural and Food Chemistry* 53(21): 8190-8196.

Nithya, K. and Muthumary, J. (2010). Secondary metabolite from *Phomopsis* sp. isolated from *Plumeria acutifolia Poiret*. *Recent Research of Science and Technology* 2(4):99–103.

Ong, C. O. (1998). *Preservation and Enhanced Stabilization for Latex*. U.S: Patent 5840790.

O'Donnell, K., Lutzoni, F. M., Ward, T. J. and Benny, G. L. (2001). Evolutionary relationships among mucoralean fungi (Zygomycota): evidence for family polyphyly on a large scale. *Mycologia* 93(2): 286-297.

OECD Guidelines for the Testing of Chemicals, Section 1; Test Guideline 115: Surface Tension of Aqueous Solutions. (1995). OECDiLibrary.

Oren, Z. and Shai, Y. (1998). Mode of action of linear amphipathic α-helical antimicrobial peptides. *Peptide Science* 47(6): 451-463.

Pacwa-Płociniczak, M., Płaza, G. A., Piotrowska-Seget, Z. and Cameotra, S. S. (2011). Environmental applications of biosurfactants: Recent advances. *International Journal of Molecular Sciences* 12(1): 633-654.

Padan, E., Bibi, E., Ito, M. and Krulwich, T. A. (2005). Alkaline pH homeostasis in bacteria: New insights. *Biochimica et Biophysica Acta (BBA)-Biomembranes* 1717(2): 67-88.

Paul, E. A. (2006). *Soil microbiology, ecology and biochemistry*. Oxford, UK: Academic press.

Pavithra, N., Sathish, L., and Ananda, K.(2012). Antimicrobial and enzyme activity of endophytic fungi isolated from tulsi. *Journal Of Pharmaceutical and Biomedical Sciences* 16(12); 1-6.

Peiming, D., and Beilong, Z. (2007). Development of natural rubber latex coagulation technologies. *Chinese Journal of Tropical Agriculture* 2: 018.

Perera, H. D. W. M., Coomarasamy, A. and Tillakaratne, L. M. K. *Effect of nitrobenzene and other photoactivators of photochemical reactions of natural rubber and model olefins.* Paper presented at the 37th Annual Session of the Sri Lanka Association for the Advancement of Science, Colombo. Dec 1981.

Prem Anand, T., Abdul Wajid, B., Shouche, Y.S., Roy, U., Siddharth, J. and Sarma, P. (2006). Antimicrobial activity of marine bacteria associated with sponges from the waters off the coast of south east india. *Microbiological Research* 161(3): 252–262.

Harley, J. P. and Prescott, L. M. (2002). *Laboratory Exercises in microbiology*, Fifth Edition. New York: The Mcgraw-Hill Companies.

Raaijmakers, J. M., Vlami, M. and De Souza, J. T. (2002). Antibiotic production by bacterial biocontrol agents. *Antonie van Leeuwenhoek* 81(1-4): 537-547.

Rabea, E.I., Badawy, M.E.T., Christian, V.S., Smagghe, G. and Steurbaut, W. (2003). Chitosan as antimicrobial agent: applications and mode of action. *Biomacromolecules* 4 (6): 1457–1465.

Radulovic, J., Sefiane, K. and Shanahan, M. E. (2009). On the effect of pH on spreading of surfactant solutions on hydrophobic surfaces. *Journal of Colloid and Interface Science* 332(2): 497-504.

Rama Rao, P. S., John, C. K., Ng, C. S., Smith, M. G. and Robert, C. F. (1976). *Commercial Exploitation of TMTD/Zinc Oxide Preservative System.* In Proceedings of the Rubber Research Institute of Malaysia Planters' Conference, Kuala Lumpur. 1976.

Rattanachaikunsopon, P. and Phumkhachorn, P. (2010). Lactic acid bacteria: their antimicrobial compounds and their uses in food production. *Annals of Biological Research* 1(4): 218-228.

Rau, U., Manzke, C. and Wagner, F. (1996). Influence of substrate supply on the production of sophorose lipids by *Candida bombicola* ATCC 22214. *Biotechnology Letters* 18(2): 149-154.

Retief, E., Damm, U., Van Niekerk, J. M., McLeod, A. And Fourie, P. H. (2005). A protocol for molecular detection of *Phaeomoniella chlamydospora* in grapevine wood: research in action. *South African Journal of Science* 101(3 & 4): 139-142.

Reznik, G. O., Vishwanath, P., Pynn, M. A., Sitnik, J. M., Todd, J. J., Wu, J. and Jarrell, K. A. (2010). Use of sustainable chemistry to produce an acyl amino acid surfactant. *Applied Microbiology and Biotechnology* 86(5): 1387-1397.

Richter, M., Willey, J. M., Süßmuth, R., Jung, G. and Fiedler, H. P. (1998). Streptofactin, a novel biosurfactant with aerial mycelium inducing activity from *Streptomyces tendae* Tü 901/8c. *FEMS Microbiology Letters* 163(2): 165-171.

Riley, M. A. and Wertz, J. E. (2002). Bacteriocins: evolution, ecology, and application. *Annual Reviews in Microbiology* 56(1): 117-137.

Rippel, M. M. and Galembeck, F. (2009). Nanostructures and adhesion in natural rubber: New era for a classic. *Journal of the Brazilian Chemical Society* 20(6): 1024-1030.

Rippel, M. M., Lee, L. T., Leite, C. A. and Galembeck, F. (2003). Skim and cream natural rubber particles: Colloidal properties, coalescence and film formation. *Journal of Colloid and Interface Science* 268(2): 330-340.

Ristow, H. (1977). The peptide antibiotic gramicidin D: A specific reactivator of tyrocidine-inhibited transcription. *Biochemistry and Biophysics* 477: 177-184.

Riyajan, S. A. and Santipanusopon, S. (2010). Influence of ammonia concentration and storage period on properties field NR latex and skim coagulation. *KGK. Kautschuk, Gummi, Kunststoffe*, 63(6).

Ron, E. Z. and Rosenberg, E. (2002). Biosurfactants and oil bioremediation. *Current Opinion In Biotechnology* 13(3): 249-252.

Rosen, M. J. and Kunjappu, J. T. (2012). *Surfactants and Interfacial Phenomena*. New Jersey: John Wiley & Sons, Inc, Hoboken.

Rosenberg, E. and Ron, E. Z. (1999). High-and low-molecular-mass microbial surfactants. *Applied Microbiology and Biotechnology* 52(2): 154-162.

Ross, P., Mayer, R. and Benziman, M. (1991). Cellulose biosynthesis and function in bacteria. *Microbiological Reviews* 55(1): 35-58.

Ross, R.P. and Morgan, S. (2002). Preservation and fermentation: past,present and future. *International Journal of Food Microbiology* 79: 3-16

Roy, R.V., Das, M., Banerjee, R. and Bhowmick, A.K. (2006). Comparative studies on rubber biodegradation through solid-state and submerged fermentation. *Process Biochemistry* 41: 181-186.

Rudzki, E. and Rebandel, P. (1998). Allergy to tetramethylthiuram disulphide, a component of pesticides and rubber. *Annals of Agricultural and Environmental Medicine* 5(1): 21-23.

Safari, A., Akbarzadeh-Khayavi, Roayaei-Ardakani and Motamedi. (2011). Isolation of biosurfactant-producing bacteria from the caspian sea and determination of their biosurfactant activity. *Journal of Kashan University of Medical Sciences*, Winter 15(4): 331-337.

Saharan, B. S., Sahu, R. K. and Sharma, D. (2011). A review on biosurfactants: fermentation, current developments and perspectives. *Genetic Engineering Biotechnology Journal* 2011:14.

Saikia, R. R., Deka, S., Deka, M. and Banat, I. M. (2012). Isolation of biosurfactant-producing *Pseudomonas aeruginosa* RS29 from oil-contaminated soil and evaluation of different nitrogen sources in biosurfactant production. *Annals of Microbiology* 62(2): 753-763.

Sameh, M.I.S., Zdenka Policova, A. and Wilhelm, N. (2011). Design and accuracy of pendant drop methods for surface tension measurement. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 384: 442– 452.

Sanderson, W. T., Hein, M. J., Taylor, L., Curwin, B. D., Kinnes, G. M., Seitz, T. A. and Bridges, J. H. (2002). Surface sampling methods for *Bacillus anthracis* spore contamination. *Emerging Infectious Diseases* 8(10): 1145-51.

Sansatsadeekul, J., Sakdapipanich, J., and Rojruthai, P. (2011). Characterization of associated proteins and phospholipids in natural rubber latex. *Journal of Bioscience and Bioengineering* 111(6): 628–634.

Satchuthananthavale, R., and Satchuthananthavale, V. (1971). Bacterial coagulation of latex. *Journal of Rubber Institute Ceylon* 48: 182-191.

Scherlach, K., Hertweck, C. and Graupner, K. (2013). Molecular bacterial-fungal interactions with impact on the environment, food and medicine. *Annual Review of Microbiology* 67(1).

Schloman, W.W. J. (2002). *Surfactant Treatment Reduces Both Allergen Content and Cure Efficiency of Hevea Latex*. Trends in new crops and new uses, Alexandria, VA: ASHS Press.

Sethuraj, M. R. and Mathew, N. T. ((1992). *Natural rubber: biology, cultivation and technology* [Electronic Version]. Elsevier, Vol. 23.

Shu, R. G., Wang, F. W., Yang, Y. M., Liu, Y. X., and Tan, R. X. (2004). Antibacterial and xanthine oxidase inhibitory cerebrosides from *Fusarium* sp. IFB-121, and endophytic fungus in *Quercus variabilis*. *Lipids* 39(7): 667-673.

Shum, K. C.; Wren, W. G. (1977). Observations on bacterial activity in natural rubber latex plate counts of latex bacteria on a supplemented medium. *Journal of the Rubber Research Institute of Malaysia* 25(2): 69-80.

Shusterman, D. (1992). Critical review: The health significance of environmental odor pollution. *Archives of Environmental Health: An International Journal*, 47(1): 76-87.

Silo-Suh, L. A., Lethbridge, B. J., Raffel, S. J., He, H., Clardy, J. and Handelsman, J. (1994). Biological activities of two fungistatic antibiotics produced by *Bacillus cereus* UW85. *Applied and Environmental Microbiology* 60(6): 2023-2030.

Silva, W. P. K., Deraniyagala, S. A., Wijesundera, R. L. C., Karunanayake, E. H., and Priyanka, U. M. S. (2002). Isolation of scopoletin from leaves of *Hevea brasiliensis* and the effect of scopoletin on pathogens of *H. brasiliensis*. *Mycopathologia* 153(4): 199-202.

Sim, L., Ward, O.P. and Li, Z.Y. (1997). Production and characterisation of a biosurfactant isolated from *Pseudomonas aeruginosa* UW-1. *Journal of Industrial Microbiology and Biotechnology; Biomedical and Life Sciences.* 19(4): 232- 238.

Sivasithamparam, K. and Ghisalberti, E. L. (1998). Secondary metabolism in *Trichoderma* and *Gliocladium*. *Trichoderma and Gliocladium: Basic Biology, Taxonomy and Genetics* 1: 139-191.

Soeseno, S. and Mansjoer, M. Influence of Microorganisms on Coagulation of Skim Latex. In Proceedings of the International Rubber Conference, Kuala Lumpur, Malaysia. Rubber Research Institute of Malaysia Ed.: Malaysia, 1975.

Sood, A., and Awasthi, S. K. (2003). Initial droplet size distribution in miniemulsion polymerization. *Journal of Applied Polymer Science* 88(14): 3058-3065.

Southorn, W. A. (1960). Complex particles in *Hevea* latex. *Nature* 188: 165 – 166.

Southorn, W.A. and Yip, E. (1968). Latex flow studies: III. Electrostatic considerations in the colloidal stability of fresh *Hevea* latex. *Journal of Rubber Research Institute Malaya* 20: 201–215.

Sridee, J. 2006. Rheological Properties of Natural Rubber Latex, PhD Thesis, Suranaree University of Technology, Thailand.

Stackebrandt, E., Keddie, R. M., and Jones, D. 2006. The Genus Kurthia. In *The Prokaryote,* ed. M. Dworkin, and S. Falkow, pp. 519-529. US: Springer.

Stauffer, C.E. (1964). The measurement of surface tension by the pendant drop technique. *The Journal of Physical Chemistry* 69(6): 1933-1938.

Subroto, T., Van Koningsveld, G. A., Schreuder, H. A., Soedjanaatmadja, U. and Beintema, J. J. (1996). Chitinase and β-1, 3-glucanase in the lutoid-body fraction of *Hevea* latex. *Phytochemistry* 43(1): 29-37.

Tadros, T. F. (2006). *Applied surfactants:Principle and Application*. German: Wiley-VCH Verlag GmbH & Co. KGaA.

Tadros, T.F. (2013). *Emulsion formation, stability, and rheology*: *In Emulsion Formation and Stability.* German: Wiley-VCH Verlag GmbH & Co. KGaA.

Tan, K. H. (2005). *Soil sampling, preparation and analysis*. Florida: CRC press.

Tanasupawat, S.,Hashimoto, Y., Ezaki, T., Kozaki, M. and Komagata, K. (1992). *Staphylococcus piscifermentans* sp. nov., from Fermented Fish in Thailand. *International Journal of Systematic Bacteriology* 42 (4): 577–581.

Tata, S.J. (1980). Distribution of proteins between the fractions of *Hevea* latex separated by ultracentrifugation. *Journal of Rubber Research* 28: 77-85.

Taysum, D. H. (1958). The numbers and growth rates of the bacteria in *Hevea* latex, ammoniated field latex and ammoniated latex concentrate. *Journal of Applied Microbiology* 21(2): 161-173.

Taysum, D. H. The establishment of a bacterial population of latex vessesls during normal tapping; Microbial latex II. In *Journal of Rubber Research*, Proceeding of the National Rubber Research Conference, Kuala Lumpur, Malaysia, Sept. 26-Oct. 1, 1960. Rubber Research Institute of Malaysia Ed.: Malaysia, 1960.

Thavasi, R., Jayalakshmi, S. and Banat, I. M. (2011). Effect of biosurfactant and fertilizer on biodegradation of crude oil by marine isolates of *Bacillus megaterium*, *Corynebacterium kutscheri* and *Pseudomonas aeruginosa*. *Bioresource Technology* 102(2): 772-778.

Thimon, L., Peypoux, F. and Michel, G. (1992). Interactions of surfactin, a biosurfactant from *Bacillus subtilis*, with inorganic cations. *Biotechnology Letters* 14(8): 713-718.

Thimon, L., Peypoux, F., Maget-Dana, R., Roux, B. and Michel, G. (1992) Interactions of bioactive lipopeptides, iturin A and surfactin from *Bacillus subtilis*. *Biotechnology Applied Biochemistry* 16: 1799-1904.

Tichaczek, P. S., Nissen-Meyer, J., Nes, I. F., Vogel, R. F. and Hammes, W. P. (1992). Characterization of the bacteriocins curvacin A from *Lactobacillus curvatus* LTH1174 and sakacin P from *L. sakei* LTH673. *Systematic and Applied Microbiology* 15(3): 460-468.

Tillekaratne, L. M. K. 1990. Types of Concentrated Latex and Testing Procedures. http://webcache.googleusercontent.com/search?q=cache:faIbQlrvNDMJ:dl.nsf.ac.lk/bitstream/1/9247/2/BRRISL-27-1.pdf%20. Retrieved 23 February 2013.

Tinkler, J., Gott, D. and Bootman, J. (1998). Risk assessment of dithiocarbamate accelerator residues in latex-based medical devices: Genotoxicity considerations. *Food and Chemical Toxicology* 36(9): 849-866.

Toxicological Profile for Ammonia; Public Health Statement for Ammonia, Agency for Toxic Substances and Disease Registry: Atlanta, GA, 2011.

Treichel, H., de Oliveira, D., Mazutti, M. A., Di Luccio, M. and Oliveira, J. V. (2010). A review on microbial lipases production. *Food and Bioprocess Technology* 3(2): 182-196.

Ulrich, H., Anthony, D. W., Gesa, F., Matthee, G. M. K., Siegfried, D., Hans-Jürgen, A. and Schulz, B. (2000). Fungi from marine sponges: Diversity, biological activity and secondary metabolites. *Mycological Research* 104(11): 1354–1365.

Umar, H. Y., Giroh, D. Y., Agbonkpolor, N. B. and Mesike, C. S. (2011). An overview of world natural rubber production and consumption: An implication for economic empowerment and poverty alleviation in Nigeria. *Journal of Human Ecology-New Delhi* 33(1): 53.

Van Gils, G. E. (1977). The solubilization of sulfur in the latex vulcanization process. *Rubber Chemistry and Technology* 50(1): 141-144.

Van Hamme, J. D., Singh, A. and Ward, O. P. (2006). Physiological aspects: Part 1 in a series of papers devoted to surfactants in microbiology and biotechnology. *Biotechnology Advances* 24(6): 604-620.

Viñas, M., Rabanal, F., Benz, R., Vinuesa, T. and Fuste, E. (2014). *Perspectives in the Research on Antimicrobial Peptides*, Berlin Heidelberg: Springer.

Vivayganathan, K., Amir, H.M.Y. and Faridah Hanim, A.B. *Environmental-friendly natural rubber latex preservation systems*. Paper presented in the International Rubber Conference and Exhibition, Kuala Lumpur. Oct 2008.

Vicedo, B., López, M. J., Asíns, M. J. and López, M. M. (1996). Spontaneous transfer of the Ti plasmid of *Agrobacterium tumefaciens* and the nopaline catabolism plasmid of A. radiobacter strain K84 in crown gall tissue. *Phytopathology* 86(5): 528-534.

Vollenbroich, D. (1997) Antimycoplasma properties and applications in cell culture of surfactin, a lipopeptide antibiotic from *Bacillus subtilis*. *Applied Environmental Microbiology* 63: 44-49.

Vrkoč, J., Buděšinsky, M. and Dolejš, L. (1977). Phenolic meroterpenoids from the basidiomycete *Albatrellus ovinus*. *Phytochemistry* 16(9): 1409-1411.

Wang, Q. and Xu, L. (2012). Beauvericin, a bioactive compound produced by fungi: A short review. *Molecules* 17(3): 2367-2377.

Walsh, T. J. and Dixon, D. M. (1989). Nosocomial aspergillosis: environmental microbiology, hospital epidemiology, diagnosis and treatment. *European Journal of Epidemiology* 5(2): 131-142.

Watanabe, T. (2011). *Pictorial atlas of soil and seed fungi: morphologies of cultured fungi and key to species*. Florida: CRC press.

Weber, D., Gorzalczany, S., Martino, V., Acevedo, C., Sterner, O. and Anke, T. (2005). Metabolites from endophytes of the medicinal plant Erythrina crista-galli. *Journal of Nature Research* 60: 467-477.

Webster, J. and Weber, R. (1980). *Introduction to fungi (Vol. 667).* Cambridge: Cambridge University Press.

Whipps, J. M. (2001). Microbial interactions and biocontrol in the rhizosphere. *Journal of Experimental Botany* 52(suppl 1): 487-511.

White, D. A., Hird, L. C. and Ali, S. T. (2013). Production and characterization of a trehalolipid biosurfactant produced by the novel marine bacterium *Rhodococcus* sp. strain PML026. *Journal of Applied Microbiology* 115(3): 744-755.

Wiemann, P. and Keller, N. P. (2013). Strategies for mining fungal natural products. *Journal of Industrial Microbiology and Biotechnology*: 1-13.

Wilkins, K., Nielsen, K. F. and Din, S. U. (2003). Patterns of volatile metabolites and nonvolatile trichothecenes produced by isolates of *Stachybotrys, Fusarium, Trichoderma, Trichothecium* and *Memnoniella*. *Environmental Science and Pollution Research* 10(3): 162-166.

Willey, J. M., Sherwood, L. and Woolverton, C. J. (2011). *Prescott's microbiology*. New York: McGraw-Hill.

Wititsuwannakul, R., Pasitkul, P., Kanokwiroon, K. and Wititsuwannakul, D. (2008). A role for a *Hevea* latex lectin-like protein in mediating rubber particle aggregation and latex coagulation. *Phytochemistry* 69(2): 339-347.

Wong, N.P., John, C.K. and Chin, H.C. (1986). Environmentally acceptable natural rubber latex from Malaysia. *Planters Bulletin RRIM* 188: 97-101.

World Organisation for Animal Health (OIE). *Terrestrial Animal Health Code: Glossary*.http://www.oie.int/fileadmin/home/eng/health_standards/tahc/2010/en_glossaire.htm. Retrieved 16 February 2012.

Wren, W. G. (1961). The Chemistry of Natural Rubber Production. *Rubber Chemistry and Technology* 34(2): 378-412.

Xenakis, A., Papadimitriou, V., & Sotiroudis, T. G. (2010). Colloidal structures in natural oils. *Current Opinion in Colloid and Interface Science* 15(1): 55-60.

Yakimov, M. M., Timmis, K. N., Wray, V. and Fredrickson, H. L. (1995). Characterization of a new lipopeptide surfactant produced by thermotolerant and halotolerant subsurface *Bacillus licheniformis* BAS50. *Applied and Environmental Microbiology* 61(5): 1706-1713.

Yildirim, Z. and Johnson, M. (1998). Characterization and antimicrobial spectrum of bifidocin B, a bacteriocin produced by *Bifidobacterium bifidum* NCFB 1454. *Journal of Food Products* 61:47–51.

Yildirim, Z., Winters, D. and Johnson, M. (1999). Purification, amino acid sequence and mode of action of bifidocin B produced by *Bifidobacterium bifidum* NCFB 1454. *Journal of Applied Microbiology* 86:45–54.

Yilmaz, M. T. (2012). Minimum inhibitory and minimum bactericidal concentrations of boron compounds against several bacterial strains. *Turkish Journal of Medical Sciences* 42(Sup. 2): 1423-1429.

Yip, E. and Cacioli, P. (2002). The manufacture of gloves from natural rubber latex. *Journal of Allergy and Clinical Immunology* 110(2): S3-S14.

Yu, J. H. and Keller, N. (2005). Regulation of secondary metabolism in filamentous fungi. *Annual Review of Phytopathology* 43: 437-458.

Yu, H., Zhang, L., Li, L., Zheng, C., Guo, L., Li, W. and Qin, L. (2010). Recent developments and future prospects of antimicrobial metabolites produced by endophytes. *Microbiological Research* 165(6): 437-449.

Yun, J. S., Wee, Y. J. And Ryu, H. W. (2003). Production of optically pure l (+)-lactic acid from various carbohydrates by batch fermentation of *Enterococcus faecalis* RKY1. *Enzyme and microbial technology* 33(4): 416-423.

Yunyongwattanakorn, J., Tanaka, Y., Kawahara, S., Klinklai, W. and Sakdapipanich, J. (2003). Effect of non-rubber components on storage hardening and gel formation of natural rubber during accelerated storage under various conditions. *Rubber Chemistry and Technology* 76(5): 1228-1240.

Zhang, Y., and Miller, R. M. (1992). Enhanced octadecane dispersion and biodegradation by a *Pseudomonas* rhamnolipid surfactant (biosurfactant). *Applied and Environmental Microbiology* 58(10): 3276-3282.

Zhang, Y., Mu, J., Feng, Y., Kang, Y., Zhang, J., Gu, P.J., Wang, Y., Ma, L.F. and Zhu, Y.H. (2009). Broad-spectrum antimicrobial epiphytic and endophytic fungi from marine organisms: Isolation, bioassay and taxonomy. *Marine Drugs* 7: 97-12.

Zhao, J., Shan, T., Huang, Y., Liu, X., Gao, X., Wang, M., Jiang, W. and Zhou, L. (2009). Chemical composition and in vitro antimicrobial activity of the volatile oils from *Gliomastix murorum* and *Pichia guilliermondii*, two endophytic fungi in *Paris polyphylla var. yunnanensis*. *Nature Product Communication* 4:1491–1496.

Zhao, J., Mou, Y., Shan, T., Li, Y., Zhou, L., Wang, M. and Wang, J. (2010). Antimicrobial metabolites from the endophytic fungus *Pichia guilliermondii* isolated from *Paris Polyphylla var. Yunnanensis*. *Molecules* 15:7961–7970.

Zhuang, X., Gao, J., Ma, A., Fu, S. and Zhuang, G. (2013). Bioactive molecules in soil ecosystems: Masters of the underground. *International Journal of Molecular Sciences* 14(5): 8841-8868.

Zyska, B.J. 1981. Rubber. In *Microbial Biodeterioration: Economic Microbiology Vol. 6,* ed. A.H. Rose, pp. 323-285. London: Academic Press.

da Silva, G. P., Mack, M. and Contiero, J. (2009). Glycerol: a promising and abundant carbon source for industrial microbiology. *Biotechnology Advances* 27(1): 30-39.

de Aguiar, H. B., Strader, M. L., de Beer, A. G. and Roke, S. (2011). Surface structure of sodium dodecyl sulfate surfactant and oil at the oil-in-water droplet liquid/liquid interface: a manifestation of a nonequilibrium surface state. *The Journal of Physical Chemistry B* 115(12): 2970-2978.

de Souza, R. C., Fernandes, J. B., Vieira, P. C., da Silva, M. F. D. G., Godoy, M. F., Pagnocca, F. C. and Pirani, J. R. (2005). A new imidazole alkaloid and other constituents from *Pilocarpus grandiflorus* and their antifungal activity. *Journal of Nature Research* 60(7): 787.

d'Auzac, J., Jacob, J. L. and Chrestin, H. *Physiology of rubber tree latex. The laticiferous cell and latex-a model of cytoplasm*. CRC Press Inc., 1989.

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LIST OF PUBLICATIONS

Aziana, A.H., Amir-Hashim, M.Y. and Zuhainis S.W. (2015). Efficiency of Commercial Biological Compounds as Anti-Coagulant Agents in Natural Rubber Latex. *Journal of Rubber Research*. (Accepted).

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Aziana, A.H., Manroshan, S., Zuhainis, S.W. and Rosfarizan, M. (2014). Microbial Surfactant as Biological Surface Active Agent in Natural Rubber Latex. *Journal of Applied Microbiology.* (Submitted).

Aziana, A.H., Manroshan, S., Zuhainis, S.W. and Rosfarizan, M. *Microbial Surfactant for Preservation of Natural Rubber Latex*. Proceedings of the International Conference on Beneficial Microbes, ParkRoyale Resort, Batu Feringghi, Penang, Malaysia. May 27-29, 2014. p.55.

Aziana, A.H., Manroshan, S., Zuhainis, S.W. and Rosfarizan, M. *Preservation of Natural Rubber Latex by Locally Isolated Microorganisms*. Proceedings of the 13th Symposium of the Malaysian Society of Applied Biology, Legend Resort, Cherating, Pahang, Malaysia. June 8-10, 2014. p.32.

Aziana, A.H., Manroshan, S., Zuhainis, S.W. and Rosfarizan, M. *Biosurfactant in Natural Rubber Latex*. National Postgraduate Seminar, Universiti Putra Malaysia, Serdang, Malaysia. September 10, 2014. p.42.

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