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NATURAL RUBBER LATEX NANOCOMPOSITES; EFFECT OF MONTMORILLONITE CLAY STRUCTURE ON REINFORCEMENT AND EXTRACTABLE PROTEINS

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Thesis submitted in partial fulfilment of the requirements for the degree of
Master of Philosophy

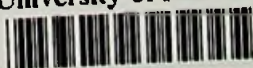
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ABSTRACT

Natural rubber (NR) latex-clay nanocomposite (NRLCN) prepared with montmorillonite (MMT) clay aqueous dispersion was evaluated for reinforcement, extractable proteins and barrier properties. Physio-mechanical properties of the NRLCN were compared with conventional NR latex composites containing CaCO_3 . The NRLCN structure was characterized with X-ray diffraction and scanning electron microscope (SEM) techniques. X-ray diffraction data showed that, with a lower concentration of clay, highly exfoliated clay structure was achieved whilst clay aggregation gradually resulted with a higher concentration of clay.

Crosslink density and volume fraction of rubber in the swollen gel as computed based on the solvent absorption data of the latex nanocomposite films increased while molar mass between crosslink of the rubber decreased with the increase of clay concentration. As a result of nano scale dispersion of montmorillonite clay and higher crosslink density of the latex nanocomposite films, resistance to permeation of small molecules through the NRLCN is significantly enhanced in comparison to conventional NR latex- CaCO_3 composites.

Solid state mechanical properties of NRLCNs have shown a significant reinforcement effect of dispersed nanoclay platelets but without sacrificing the elastic properties. Results have been explained in terms of degree of clay dispersion/exfoliation, crosslink density and strain induced crystallization.

The extractable protein content was analysed for the NRLCN samples using the Modified Lowry Method. It had shown a significant reduction of the extractable protein content in the NR latex films when montmorillonite clay is introduced. The NRLCNs were leached using typical industrial leaching conditions and also tested for the extractable protein content which dropped well below the allergenicity level of human skin. The extractable protein content of raw NR latex-clay un-vulcanized films had shown similar results as the NRLCN which confirms the attraction of protein cations with the nanoclay platelets. The entrapped protein has accelerated the vulcanization reaction of the NRLCN which caused higher crosslink density. Higher mechanical properties, very low extractable protein content and improved barrier resistance indicated that NR latex nanocomposite containing montmorillonite clay is a potential replacement for conventional NR latex composites containing CaCO_3 .

Keywords: Natural rubber latex/ clay/ nanocomposites/ physical properties/ barrier properties/ exfoliation/ crosslink density/ Latex allergies/ Extractable proteins

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LIST OF ABBREVIATIONS

ASTM	- American Society of Testing and Materials
BA	- Boric acid & Lauric acid
CaCO ₃	- Calcium Carbonate
CDRH	- Center for Devices and Radiological Health
CEC	- Cation Exchange Capacity
DRC	- Dry Rubber Content
ELISA	- Enzyme Linked Immunosorbent Assay
FDA	- Food and Drug Administration
FEV	- Forced Expiration Volume
FTIR	- Fourier Transform Infrared Spectroscopy
HA	- High Ammonia
Hev b	- Hevin b
HIV	- Human Immunodeficiency Virus
IgE	- Immunoglobulin E
KOH No	- Potassium Hydroxide number
LA	- Low Ammonia
LATZ	- Low Ammonia latex preserved with ZnO and TMTD
MMT	- Montmorillonite .
MST	- Mechanical Stability Time,
NH ₄ OH	- Ammonium Hydroxide
NHANES	- National Health and Nutrition Examination Survey
NIOSH	-National Institute of Occupational Safety and Health

NMR	- Nuclear Magnetic Resonance Spectroscopy
NR LATEXCN	- NR latex/clay nanocomposite
NR	- Natural Rubber
NRL	- Natural Rubber Latex
ODE	- Office of Device Evaluation
OMLS	-Organically Modified Layered Silicate
PEO	- Poly Ethylene Oxide
PVA	- Poly Vinyl Alcohol
RVNR latex	-Radiation Vulcanized Natural Rubber latex
SEM	- Scanning Electron Microscopy
SSP	- Sodium pentachloro phenate
TEM	- Transmission Electron Microscopy
TGA	- Thermal Gravimetric Analysis
TMTD	- Tetra Methyl Thiuram Disulphide
TSC	- Total Solid Content
U.S.	- United States
USP	- United States Pharmacopoeia
VFA	-Volatile Fatty Acid Number
XRD	- X- Ray Diffraction
ZDEC	- Zinc Diethyldithio Carbamate
ZnO	- Zinc Oxide