TechnoBiz

RUBBER Review

Co-Publishers
RubberWorld
中联橡胶股份有限公司
CHINA UNITED RUBBER CORPORATION

Issue-42 | October 2026 | https://publication.technobiz.org

Prof. Masami Okamoto

Toyota Technological Institute, Japan

TechnoBiz

GRTE

7TH Global Rubber Latex & Tyre Expo

10-12 MARCH 2027

BITEC, BANGKOK, THAILAND

TechnoBiz

中联橡胶股份有限公司
CHINA UNITED RUBBER CORPORATION

https://events.technobiz.org

GRTE

7TH Global Rubber Latex & Tyre Expo

10-12 MARCH 2027
BITEC, BANGKOK

TechnoBiz | 中联橡胶股份有限公司 CHINA UNITED RUBBER CORPORATION

Co-Located Events

RUBBER WEEK
A TechnoBiz Executive Forum on Rubber Technology & Industry

Tyre Tech WEEK
A TechnoBiz Executive Forum on Tyre Technology & Industry

LATEX WEEK
A TechnoBiz Executive Forum on Latex Technology & Industry

YOUNG RUBBER RESEARCHER FORUM
A TechnoBiz Forum for Young Rubber Researchers

งานประชุมยางไทย THAILAND RUBBER CONFERENCE
National Conference for Thai Rubber Industry

RUBBER CEO Dinner
Professional Networking Event for Rubber & Tyre Industry CEOs

WORLD OF RUBBER HALL OF FAME
Award Event for Rubber Industry Icons

Emissions Analytics TYRE EMISSIONS & SUSTAINABILITY ASIA 2027
International Conference on Tyre Emissions & Sustainability

RUBBER MARKET FORUM
A TechnoBiz Executive Forum on Global Rubber Industry Outlook

RUBBER CIRCULARITY FORUM
A TechnoBiz Executive Forum on Rubber Circularity & Sustainability

NATURAL RUBBER FORUM
A TechnoBiz Executive Forum on Natural Rubber Industry

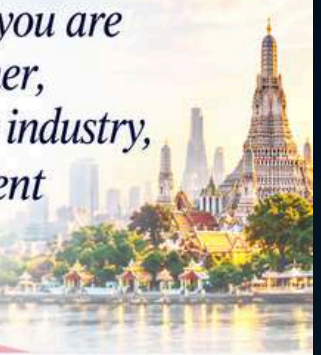
RUBBER RESEARCH FAIR
International Poster Fair on Rubber Research & Innovations

RUBBER Book Fair
A TechnoBiz Fair on Books for Rubber Professionals

TALENT Connect
Showcase of Job Opportunities in Rubber & Tyre Industry

GRTE CONFERENCE
GRTE Exhibitor's Conference on New Technologies & Solutions

*"No matter where you are in the world, whether you are a technical expert, business leader, researcher, manufacturer, supplier, trader or newcomer to the industry, GRTE 2027 Bangkok is a **MUST-VISIT** event for every rubber professional."*



Prof. Masami Okamoto

Toyota Technological Institute, Japan

Conversation with

Prof. Masami Okamoto

Toyota Technological Institute, Japan

Natural rubber has long been valued for its exceptional elasticity, resilience and versatility in industrial applications. However, advances in nanotechnology, materials science and biomedical engineering are opening new possibilities for natural rubber beyond conventional products. Research into natural rubber latex nanoparticles and biological composites is creating opportunities to investigate the material's potential in tissue engineering, regenerative medicine and other emerging applications.

In this edition of Rubber Review, we are pleased to feature Prof. Masami Okamoto of Toyota Technological Institute, Japan, an internationally recognized researcher whose contributions span polymer nanocomposites, advanced materials engineering and biomedical applications.

Professor Okamoto obtained his Ph.D. from Tokyo Institute of Technology in 1994. His professional journey includes industrial research experience at Toyobo Research Center, followed by an extensive academic career at Toyota Technological Institute.

His pioneering investigations into polymer-clay nanocomposites, biodegradable polymers and structure–property relationships have contributed significantly to the development of advanced polymer materials.

In recent years, his research interests have extended into natural rubber latex nanoparticles, tissue-based biological composites, cellular responses and the potential application of natural rubber-derived materials in regenerative medicine.

His contributions have received recognition from the Society of Rubber Science and Technology, Japan, including the Science and Technology Award in 2019 and the Oenslager Award in 2024.

Professor Okamoto also serves as Vice President of the Society of Rubber Science and Technology, Japan, contributing to the advancement of research and professional collaboration within the rubber community.

His scientific journey demonstrates the importance of connecting fundamental material science with emerging interdisciplinary applications.

In this cover story interview, Rubber Review explores Professor Okamoto's research achievements, scientific perspectives on natural rubber latex, challenges in developing rubber-based biomedical materials and his vision for the future of rubber science, technology and industrial innovation.

"Young rubber scientists and engineers should look beyond the traditional applications of rubber and explore its potential as a versatile material for addressing global challenges. The greatest scientific contributions emerge when fundamental knowledge, interdisciplinary research, and industrial needs come together to create meaningful value for society."

LATEX
CONFERENCE
PSU
LATEX
CONFERENCE

Scientific Journey, Research Philosophy and Contributions to Rubber Science

Your professional journey began with industrial polymer research at Toyobo Research Center, followed by doctoral studies at Tokyo Institute of Technology and an academic career at Toyota Technological Institute. What originally inspired your interest in polymer science, and which scientific experiences most strongly influenced your research direction?

My interest in polymer science began during my undergraduate years when I studied polymer chemistry, encompassing both chemical synthesis and physical properties. Later, while conducting research on polymer alloys and blends at the Toyobo Research Center, I became fascinated by how macromolecular interactions in polymer blends could be comprehensively described through thermodynamics. Driven by a desire to explore this field more deeply, I pursued doctoral studies at the Tokyo Institute of Technology, focusing on the structure and physical properties of polymer blends. Completely captivated by academic research, I transitioned to an academic career at Toyota Technological Institute, where I currently serve.

You are internationally recognized for your pioneering contributions to polymer nanocomposites, particularly polymer/clay systems. What were the most important scientific discoveries from your early research, and how have these findings influenced the development of modern rubber nanocomposites and high-performance elastomer materials?

Polymer nanocomposites have the potential to significantly impact global economic growth across various sectors in the 21st century. The rapid expansion of this field was greatly facilitated by the invention of scanning tunneling microscopy and scanning probe microscopy in the early 1980s. Nanofillers (nanomaterials) embedded in polymer nanocomposites possess an extraordinarily high interfacial area per unit volume, with interparticle distances (correlation length ξ)) on the order of polymer random coil dimensions (approx. 20 nm in diameter). Furthermore, as filler loading increases, the correlation length between particles becomes smaller than the average particle diameter D ($\xi \leq D$), creating strong geometric constraints and forming a spatially interconnected network of dispersed filler particles.

The ability of low filler concentrations to profoundly alter the host matrix polymer has driven widespread interest in polymer nanocomposites. Consequently, molecular interactions between polymer chains and nanofillers give rise to unique properties absent in conventional microcomposites. Moreover, many polymer nanocomposites—including rubber and elastomer systems—can be processed using conventional macrocomposite manufacturing techniques, making them exceptionally attractive from an industrial standpoint.

Your research philosophy emphasizes connecting academic research with industrial applications. How has your experience in both industrial and academic environments influenced the way you identify research problems? What do you consider the essential ingredients for transforming fundamental materials research into technologies that create practical value?

In the industrial sector, the primary focus centers on product quality, cost, mass-producibility, and reliability, whereas academia emphasizes elucidating novel scientific principles and underlying mechanisms. My background in industry has proven to be a vital asset when initiating and leading collaborative research projects with corporate partners. Transforming a fundamental technology into practical application requires a clear societal or industrial demand, reproducible experimental data, seamless compatibility with manufacturing processes, robust intellectual property, and effective academic-industrial partnerships—all of which I actively prioritize in my work.

Your career has progressed from polymer blends and nanocomposites to natural rubber latex nanoparticles and biomedical materials. What scientific considerations motivated this transition? How has your understanding of nanostructured polymers helped you explore new functions and applications for natural rubber?

The primary particle size of natural rubber latex (NRL) falls within the 100–300 nm range, making it a highly promising nanomaterial for drug delivery, tissue engineering, regenerative medicine, and broader biotechnological applications. Nanoparticles are typically internalized by cells via endocytosis, and in vitro studies indicate that particle sizes between 20 and 200 nm are ideal for drug delivery systems.

The surface of an NRL particle is encapsulated by a thin, ~20 nm layer composed of proteins and phospholipids. These surface proteins contain both positively and negatively charged amino acid residues, granting NRL nanoparticles a pH-dependent surface charge as these residues gain or lose protons depending on the surrounding medium. Consequently, at a physiological pH of 7.4, NRL nanoparticles exhibit a net negative zeta potential reaching approximately –70 mV. Recognizing these distinctive physicochemical traits, I immediately foresaw NRL's potential as an advanced bio-nanofiller in biotechnology.

LATEX
CONFERENCE
SPEAKER

Natural Rubber Latex Nanoparticles and Advanced Material Properties

Natural rubber latex is generally associated with conventional rubber products, but your research explores latex nanoparticles for advanced biological applications. What structural and physicochemical characteristics of natural rubber latex nanoparticles make them interesting for developing functional materials beyond traditional rubber products?

Historically, little attention was paid to the potential pharmacological activity of NRL nanoparticles, largely due to concerns surrounding latex allergenicity in sensitive individuals. However, in biomedical applications, material performance depends not only on mechanical softness, but also on how biological cells and proteins perceive the material interface. Our detailed investigations revealed that NRL exhibits extremely low cytotoxicity toward healthy normal cells (such as osteoblasts and chondrocytes), while exerting potent, concentration-dependent anticancer activity against various cancer cell lines (including lung, breast, and ovarian cancers). These discoveries suggest that the surface structure of NRL operates in a drug-like manner, actively participating in biomolecular interactions and modulating cellular signaling responses.

Natural rubber latex contains rubber particles together with non-rubber constituents, including proteins and lipids. How do particle size, surface chemistry, molecular organization and associated non-rubber components influence the behaviour of latex-derived nanomaterials? Which characteristics are particularly important when designing materials for biological applications?

Fractionated NRL comprises three main constituents isolated via ultracentrifugation: (1) a rubber hydrocarbon component (94 wt%) attributed to cis-1,4-polyisoprene; (2) an intermediate phase (5.8 wt%) composed of water-soluble components, adsorbed proteins, and surface-bound phospholipids; and (3) a sediment phase (0.2 wt%) consisting of non-rubber constituents such as inorganic ions and sterol glycosides. The sediment contains lutoid organelles involved in biochemical functions and allergic reactions, whereas the intermediate phase is directly associated with novel biological properties. One major clinical application of this intermediate phase is inhibiting liver cancer cells through non-apoptotic cell death mechanisms. While the anticancer potential of NRL has attracted significant research interest, establishing its biological safety requires rigorous evaluation of potential adverse effects and cellular interaction mechanisms. Comprehensive toxicological profiling and cytotoxicity studies remain essential to fully elucidate the biological safety and action mechanisms of NRL particles.

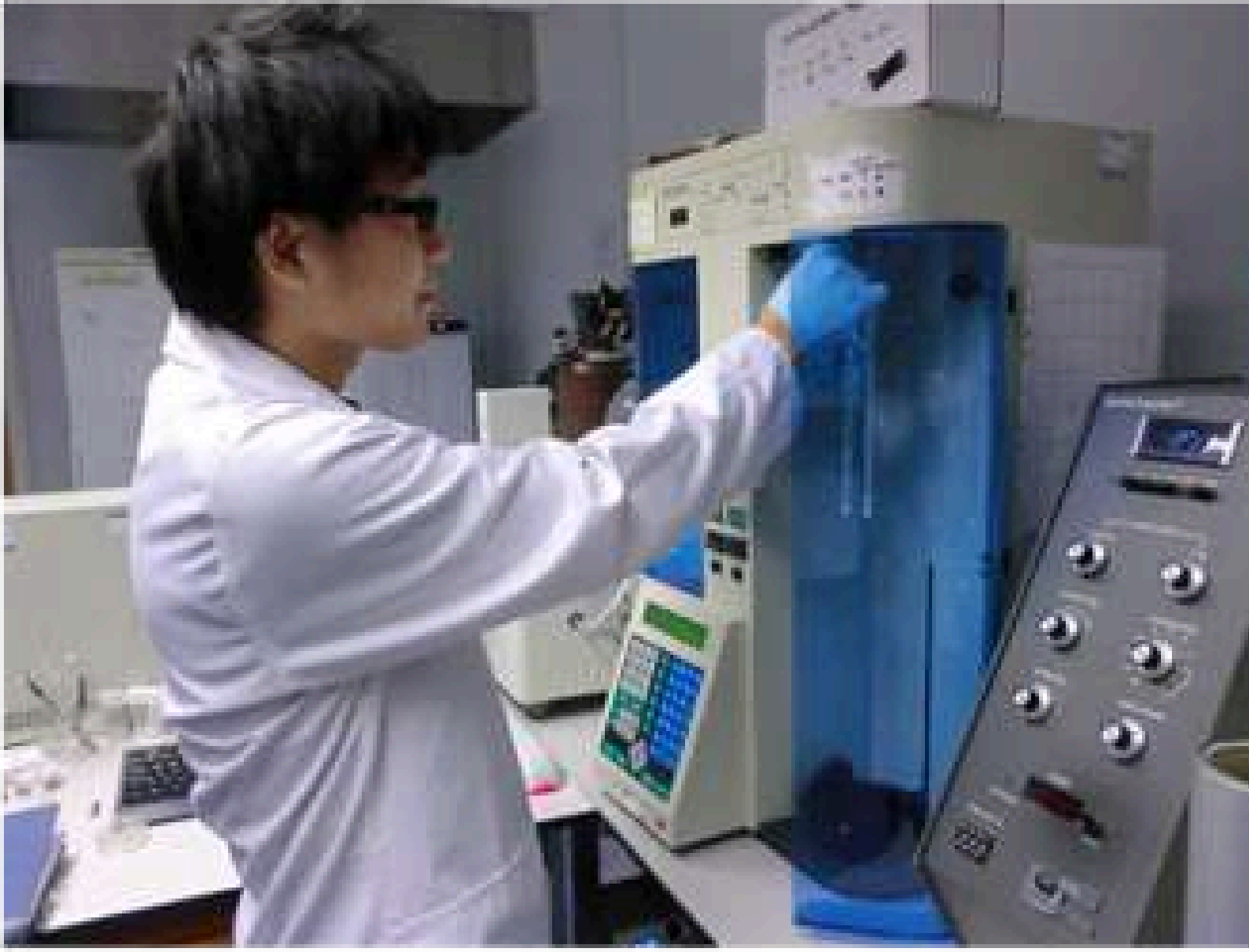
Nanostructure and interfacial interactions are central to the performance of polymer composites. Based on your research, how can controlling the dispersion, morphology and interfaces of natural rubber latex-based nanomaterials influence their mechanical, physical and functional properties? What characterization techniques are most useful for understanding these relationships?

To evaluate mechanical heterogeneity at the nanoscale, cartilage cell-based spheroids incorporating NRL nanoparticles were analyzed using atomic force microscopy (AFM) indentation. High-resolution 20 × 20 μm^2 spatial maps of adhesion and Young's modulus were constructed across the indented regions. Spheroids (approximately 600 µm in diameter) cultured with varying concentrations of NRL nanoparticles displayed significantly smoother surface topographies compared to untreated controls, while AFM nanoindentation successfully mapped local variations in stiffness across the biological composite.

Developing consistent advanced materials from natural rubber presents challenges because it is a biologically derived material with natural variability. What are the most important considerations involving latex sourcing, purification, particle stability, composition, processing and quality control when developing natural rubber-based nanomaterials for specialized applications?

Developing consistent, high-value materials from natural rubber involves addressing three core considerations:

1. *Geographical bottleneck*: Global NRL production is heavily centralized in Asia, creating supply chain constraints for clinical-grade materials at global scale.
2. *Compositional variability*: As a natural plant product, NRL's chemical composition fluctuates based on seasonal factors, soil conditions, clonal variations, and tapping methods.
3. *Standardization for clinical deployment*: Establishing rigorous quality control and standardizing active pharmaceutical components within NRL are crucial steps for reproducible pharmaceutical and medical device manufacturing.



Natural Rubber in Biomedical Applications and Regenerative Medicine

Your research on natural rubber latex-derived biological composites has received significant recognition, including the Science and Technology Award in 2019 and the Oenslager Award in 2024. What were the principal scientific findings behind these investigations, and what do you consider their most important contributions to rubber science?

While NRL nanoparticles have traditionally served industrial applications, their scope is expanding rapidly into tissue engineering. We demonstrated that NRL nanoparticles exhibit selective cytotoxicity—sparing healthy normal cells while targeting cancer cells—and recent studies confirmed their ability to induce cell cycle arrest and apoptosis. In a groundbreaking contribution to tissue engineering, our research group successfully fabricated cartilage/NRL biocomposites via human mesenchymal stem cell (hMSC) spheroid formation for the first time. These findings highlight the immense promise of NRL nanoparticles in regenerative medicine. Future efforts will focus on investigating long-term mechanical performance, preclinical biosecurity, and unraveling how NRL-regulated surface signaling governs cell development, wound healing, and tissue regeneration.

Your work has explored the anticancer activity of natural rubber latex-related materials. What observations initially suggested their potential biological activity, and what mechanisms are being investigated to explain their interactions with cancer cells? How can researchers distinguish material-specific biological effects from responses caused by impurities, associated proteins or experimental conditions?

Our group initially demonstrated the cell compatibility of NRL using cultured human lung carcinoma (A549) and mouse preosteoblast (MC3T3-E1) cells in vitro. MC3T3-E1 preosteoblasts exhibited high metabolic activity at NRL concentrations below 10.0 μg/mL, and doses up to 1.0 mg/mL induced no cytotoxic cell death. Conversely, NRL nanoparticles exhibited potent toxicity toward A549 cancer cells, reducing cell viability below 60% at 100 μg/mL and effectively inhibiting cell proliferation within 24 hours. Ongoing investigations indicate that this selective cytotoxicity is closely linked to cellular endocytosis pathways. These results establish NRL as a highly promising bio-nanoparticle capable of inducing apoptosis in cancer cells while minimizing adverse side effects on surrounding healthy human tissue.

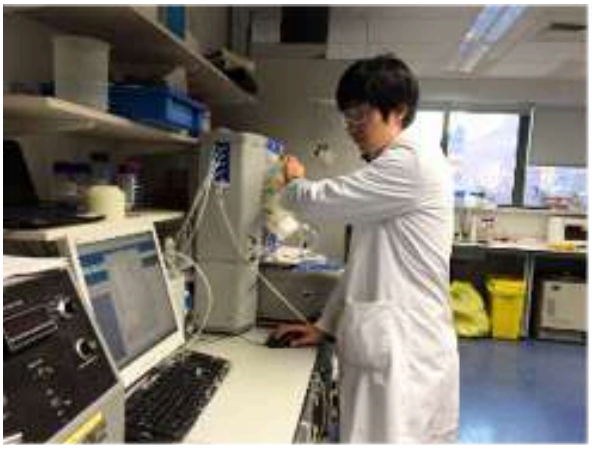
"Natural rubber latex is no longer just an industrial material; its emerging ability to selectively target cancer cells while supporting healthy cell growth opens exciting new possibilities in tissue engineering, regenerative medicine, and future biomedical applications."

Your investigations also consider natural rubber latex-based materials for tissue engineering and regenerative medicine. Which material characteristics are especially important for supporting cellular attachment, proliferation, differentiation and tissue regeneration? What advantages and limitations might natural rubber-based materials present compared with conventional synthetic biomedical polymers?

Healthy cells interact dynamically with the extracellular matrix (ECM), which spans a wide range of elastic moduli from 50 Pa to 2 GPa. Soft tissues like the lung possess low stiffness (~300 Pa), whereas load-bearing tissues like bone display stiffness several orders of magnitude higher (10^4–10^6 Pa). Natural tissues adapt continuously to their mechanical microenvironment, and biomechanical mismatches at the implant-host tissue interface can trigger structural degradation or abnormal cellular responses. Natural rubber latex exhibits an elastic modulus of approximately 400 kPa, making it biomechanically ideal for integration with soft tissues such as cartilage. Consequently, NRL nanoparticles hold great potential as load-bearing structural elements in cartilage tissue repair and regeneration.

Biocompatibility and long-term safety are essential requirements for biomedical materials. Natural rubber latex is also associated with concerns about allergenic proteins and biological variability. What approaches should researchers adopt to evaluate and address these issues? Which laboratory, preclinical and regulatory investigations are necessary before latex-derived materials can be considered for medical applications?

Our work on cartilage biocomposites containing NRL nanoparticles highlights their potential in tissue engineering, though long-term mechanical stability remains a key focus. Initial safety screening requires evaluating cytotoxicity, inflammatory response, hemolysis, sensitization, genotoxicity, and degradation products. Because cartilage tissue is avascular and devoid of dendritic cells that trigger allergic cascades, the risk of systemic inflammation or hemolysis is exceptionally low. Preclinical validation must subsequently employ animal models to evaluate local tissue compatibility, systemic toxicity, immune responses, and long-term degradation kinetics prior to clinical transition.



Rubber Nanocomposites, Biofunctional Materials and Industrial Opportunities

Your pioneering work on polymer/clay nanocomposites helped establish a scientific foundation for nanoscale reinforcement. What lessons from this research are most relevant to rubber compounds incorporating nanoclay, graphene, carbon nanotubes or other nanomaterials? How should compound designers balance reinforcement, elasticity, dynamic properties and processability?

Key lessons from polymer/clay nanocomposites center on achieving uniform nanofiller dispersion, preventing agglomeration, tailoring interfacial interactions with the elastomer matrix, and controlling network structure orientation. Excessive filler loading degrades elasticity, ultimate elongation, and processability while sharply increasing compound viscosity. In dynamic applications like tires, compound designers must balance rolling resistance, heat build-up, wear resistance, and wet grip. The optimal compounding strategy does not merely maximize static mechanical strength, but rather achieves a balanced synergy between reinforcement, elasticity, dynamic performance, and processability tailored to specific operational requirements—approaches that are already successfully commercialized.

Natural rubber nanocomposites can potentially combine conventional elastomeric performance with additional electrical, thermal, barrier or biological functions. Which multifunctional properties do you believe offer the greatest opportunities for future rubber products? What challenges must be overcome to achieve these properties without sacrificing the advantages of natural rubber?

Enhancing natural rubber beyond traditional mechanical performance opens major opportunities in multifunctional materials. Key target functionalities include electrical and thermal conductivity, gas/moisture barrier performance, strain sensing, antibacterial properties, and biocompatibility. For example, highly stretchable, conductive rubber formulations enable wearable physiological sensors and flexible bio-electronics. The primary engineering challenge lies in imparting these advanced functional capabilities without compromising the inherent high elasticity, tear strength, and fatigue resistance of natural rubber.

"The future of rubber nanocomposites lies not in maximizing mechanical strength alone, but in achieving the right balance between reinforcement, elasticity, processability, and advanced functionalities. The greatest opportunities will come from transforming natural rubber into multifunctional materials without sacrificing its inherent performance advantages."

Your research includes biodegradable polymer nanocomposites and biological materials. How should researchers evaluate sustainability when developing advanced rubber composites? What are the trade-offs involving renewable raw materials, nanofillers, product durability, degradation behaviour and end-of-life management?

Although natural rubber is inherently renewable, its environmental footprint must be evaluated across its complete lifecycle—from latex harvesting and transportation to chemical refining, compounding, and manufacturing. Nanofillers significantly enhance material performance, but their synthesis may involve high energy consumption, resource intensity, and recycling challenges. Extending product durability reduces raw material consumption, yet creates a trade-off with end-of-life biodegradability or recyclability. Therefore, sustainability assessment requires a holistic lifecycle analysis (LCA) balancing renewable sourcing, operational durability, degradability, and circular end-of-life management.

Translating laboratory research on natural rubber latex nanoparticles into practical products requires reliable manufacturing methods and consistent material quality. What do you consider the most significant challenges involving nanoparticle preparation, purification, scale-up, characterization and reproducibility? How can collaborations between rubber producers, materials scientists and biomedical companies help address these challenges?

Translating NRL nanoparticle research into commercial production presents challenges in preparation reproducibility, purification efficiency, microbial decontamination, dispersion stability during scale-up, and batch-to-batch consistency. Processing parameters and mixing/drying technologies optimized at laboratory scale often alter material structure when scaled up. Overcoming these hurdles requires close tripartite collaboration: raw material suppliers ensure stable latex feedstocks, materials scientists optimize nanostructural and physical properties, and biomedical companies navigate regulatory compliance, biosecurity, and commercialization.

Future of Rubber Science, Research Leadership and Professional Perspectives

As Vice President of the Society of Rubber Science and Technology, Japan, you have an important perspective on developments in rubber research. What scientific and technological trends do you consider most significant for the Japanese rubber industry? How can professional societies strengthen collaboration between universities, research institutions and industrial companies?

Major trends driving the Japanese rubber industry include high-performance tire formulations, decarbonized and circular materials, advanced nanocomposites, bio-based polymers, and digital material design. Professional societies play a vital role as neutral platforms connecting academia, public institutes, and industry—fostering joint research, talent development, standardization, early-career support, and knowledge transfer to bridge fundamental science with industrial needs.

The rubber industry continues to focus heavily on tyres, industrial products and conventional elastomer applications. Do you believe the next major advances in rubber science could increasingly come from interdisciplinary fields such as biomedical engineering, nanotechnology, functional surfaces and advanced biological materials? What opportunities and limitations do you foresee?

While tires and industrial goods remain core markets, integrating rubber science with biomedical engineering, nanotechnology, functional surfaces, and biomaterials creates transformative applications. Key growth areas leveraging rubber elasticity include bio-compatible interfaces, soft robotics, wearable devices, and cellular culture substrates. However, these specialized sectors demand strict safety standards, long-term biosecurity, regulatory approval, cost efficiency, and manufacturing reproducibility. Achieving success requires multidisciplinary convergence between traditional rubber compounding, cell biology, flexible electronics, and medical regulatory affairs.

Looking towards 2030 and beyond, which developments in natural rubber latex nanoparticles, rubber nanocomposites, biofunctional elastomers and advanced material characterization do you expect to have the greatest scientific and industrial impact? What role might artificial intelligence, molecular simulation and advanced manufacturing play in accelerating these developments?

Looking toward 2030, the greatest scientific and industrial impacts will arise from precision control of latex nanoparticles, high-performance rubber nanocomposites, biofunctional elastomers, and advanced structural characterization techniques. Artificial intelligence (AI)will accelerate material discovery by analyzing vast formulation and processing datasets to optimize properties. Molecular dynamics simulations will elucidate polymer-filler-interface interactions and facilitate protein structural design on latex surfaces. Furthermore, advanced continuous manufacturing and automated quality monitoring will enhance batch reproducibility and industrial scalability.

Reflecting on your scientific journey, international collaborations, research achievements and contributions to professional societies, what do you consider your most meaningful accomplishments and lessons? What advice would you offer young rubber scientists and engineers who wish to build successful research careers while connecting fundamental scientific discoveries with practical industrial and societal benefits?

My most rewarding achievement has been pioneering interdisciplinary research that advanced natural rubber latex nanoparticles into biomedical and tissue engineering applications. This journey demonstrates that combining deep domain expertise with cross-disciplinary exploration, international collaboration, and mentorship can simultaneously establish new scientific fields and create tangible societal value. Young rubber scientists and engineers should view rubber not merely as a traditional commodity, but as a versatile functional platform to address unmet global challenges. Success relies on four pillars: 1. Connecting fundamental discoveries to real-world applications |2. Embracing interdisciplinary knowledge | 3. Aligning research with industrial and societal needs |4. Building an active global research network.

TechnoBiz