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Higher regulatory standards raise bar for new antibiotics but create opportunity for low-risk, biodegradable alternatives

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In this exclusive AgroSpectrum interview, Prof. Paula Hammond, Institute Professor and Executive Vice Provost at Massachusetts Institute of Technology (MIT) and Principal Investigator at SMART AMR; Prof. Mary Chan, NTU Singaporeâ??s School of Chemistry, Chemical Engineering and Biotechnology, and the Lee Kong Chian School of Medicine and Principal Investigator at SMART AMR discuss their groundbreaking antimicrobial polymer platform poised to rewrite the rules of dairy health management.

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Addressing Bovine Mastitisâ??a $22 billion global challengeâ??they explain how Oligoimidazolium carbon acids (OIMs) and Polyimidazoliums (PIMs) deliver potent, low-dose, biodegradable protection without contaminating milk or driving antibiotic resistance. Their early farm trials in China, Malaysia, and Singapore exposed a startling technological stagnation in udder hygiene, revealing an urgent need for modern, eco-safe disinfectant solutions. With regulatory pathways complex and market systems fragmented, they outline a hybrid commercial model balancing direct product development with strategic global partnerships for scale. Their message is clear: antimicrobial innovation must now serve One Healthâ??protecting animals, consumers, and the environment in equal measure. Edited excerpts:

The Breakthrough and Its Global Context

A $22 Billion Problem: Professor Hammond, bovine mastitis is one of the costliest animal health challenges worldwide. What led your team to focus on this long-standing issue, and what scientific insight unlocked the possibility of developing oligoimidazolium carbon acids (OIMs) as a safer antimicrobial alternative?

Prof Mary Chan (my close colleague and collaborator at NTU Singapore) and I have always shared a strong interest in the generation of new polymeric materials for health applications, and we have been particularly interested in charged polymers. Through a collaboration launched by a visiting student from the Chan lab, the imidazolium set of polymers was generated and advanced.

Prof Maryâ??s lab continued to develop more active antibiotic versions and discovered a unique mechanism in this family of materials that makes them highly effective for treatment and prevention of infection. As our research team at SMART began to work toward applying these systems for human health applications, leveraging methods developed in my lab, we saw the potential for these compounds to have an immediate impact on agricultural health.

An early SMART researcher working within our shared team first began investigating the potential of the system in a small farm trial and, from that point, we have been pursuing ways in which these novel oligoimidazoliums (OIMs) can be used for safe agricultural applications.

Beyond Resistance: Antibiotic resistance has often been framed as a human health crisis, but its agricultural dimension is equally alarming. How does your research reposition the conversationâ??bridging human, animal, and environmental health under the One Health paradigm?

We developed a new class of cationic antimicrobial polymers based on carbene chemistry, so that these cationic polymers are a new class by themselves that are potent and effective in a complex environment and yet biodegradable â?? able to be degraded into smaller fragments. Our compounds are a class of main chain polyimidazoliums (PIMs)/OIMs.

By designing compounds that are effective at low doses, biodegradable, and leave negligible residues in milk, we directly address resistance, agricultural food safety concerns and ecological contamination in one stroke. In practice, that means

fewer antibiotics entering the food chain, fewer selective pressures for resistance in farm settings, and reduced downstream environmental impact.

Science to Scale: From Lab Discovery to Dairy Field

Farm Trial Insights: The initial field trials in Malaysia and Singapore showed encouraging resultsâ??no udder irritation, no milk contamination, and strong bacterial suppression. What were the most surprising learnings from translating this molecular innovation to real-world dairy operations?

Our initial farm trial was completed in China, and our ongoing farm trial is in Malaysia and Singapore. One of the most striking learnings was how little the technology in modern dairy farming has evolved for udder hygiene, especially in regard to the gap between antibiotics and disinfectants. Despite advances in overall farming practices, there arenâ??t disinfectants that are both safe and quick acting. The teat dips used today, which typically consist of iodine or chlorhexidine, are essentially the same as several decades ago. This revealed a critical gap between the growing sustainability requirements in modern agriculture and the outdated tools currently available, underscoring the urgent need for innovations like degradable PIMs that are effective, safe and environmentally friendly.

Scaling Innovation: You mentioned industry interest from Australia, Belgium, Malaysia, and New Zealand. What does it take to move from promising lab results to full-scale commercialisation in the heavily regulated animal health industry?

Commercialisation requires a coordinated program: scaled Good Manufacturing Practice (GMP) systems, larger and geographically diverse field trials, robust safety testing, regulatory dossiers for each target market, and credible industry partnerships for distribution and farmer education. Because animal health regulation is regionally fragmented, a pragmatic pathway is to pair focused pilot commercialisation in receptive markets with licensing or joint ventures for wider rollout.

The Business of Biotech and Antimicrobial Innovation

Commercialisation Pathway: The research is now transitioning to a spin-off company. What is the envisioned business modelâ??direct product commercialisation, licensing to agribusiness majors, or joint ventures with dairy cooperatives?

We envision a flexible, hybrid model. Initially, the spin-off will drive product development and secure key regulatory approvals and pilot customers. For broad, rapid deployment, we expect to pursue strategic partnerships with established agribusiness and animal health companies that already have market reach and customer relationships. Joint development agreements with regional partners will also help customise formulations and application protocols for different farming systems.

Policy Catalysts: What regulatory or policy shiftsâ??whether in the U.S., EU, or Asiaâ??would most accelerate the adoption of antibiotic alternatives like OIMs in mainstream agriculture?

Concrete regulatory actions are already reshaping antibiotic use in agriculture: the European Union (EU) prohibited the preventive use of antibiotics in groups of animals and tightened veterinary oversight under Regulation EU 2019/6. In China, the Ministry of Agriculture and Rural Affairs banned the use of most antibiotic growth promoters in animal feed in 2020. Specifically in the United States, the Food and Drug Administration (FDA) phased out growth-promotion uses via Guidance for Industry (GFI) #213; at the same time, GFI #152 requires rigorous microbiological risk assessment for any new antimicrobial in food animals. These higher regulatory standards raise the bar for new antibiotics but create an opportunity for low-risk, biodegradable alternatives like OIMs that do not select for human-relevant resistance.

Science, Systems, and Sustainability

Rethinking Animal Health: In many ways, bovine mastitis is a microcosm of global food system fragilityâ??overreliance on antibiotics, environmental pollution, and supply chain waste. How can cross-disciplinary R&D, such as SMART AMRâ??s approach, reshape the future of veterinary science?

When scientists, engineers and other experts work together, we get a better understanding of the challenges that we face and the tools that we have available to apply to them, and it is possible to see new ways of addressing decades-old problems. By keeping sustainability and safety as part of the solution requirement, we can evolve our science towards a more holistic approach in which the short and long-term outcomes are considered. Sustainable solutions can be further advanced by bringing scientists together with agricultural and veterinary experts and policy makers to better understand where and how to best focus our cross-disciplinary efforts.

The Decade Ahead: As an MIT Institute Professor and a leader in translational science, how do you see the next decade of antimicrobial R&D evolvingâ??especially in balancing synthetic chemistry, bioengineering, and planetary health imperatives?

There will be great opportunities in the coming decade to move away from more traditional antimicrobial drugs and towards innovative approaches that address microbes across a multi-spectrum fashion while reducing harm to animal health and the planet. To accomplish this goal, we will need to deploy creative materials chemistry with a deep understanding of biology and ecological considerations.

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