Proactive research and mastery of advanced material technologies for defense and security: An overview

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Received 1 Aug. 2025; Revised 26 Sep. 2025; Accepted 16 Oct. 2025; Published 18 Nov. 2025.
DOI: https://doi.org/10.54939/1859-1043.j.mst.IMBE.2025.5-7

ABSTRACT

This paper presents a comprehensive overview of the research achievements and strategic development orientations of the Institute of Materials, Biology and Environment (IMBE), Academy of Military Science and Technology (AMST), for the period 2020–2025, with vision toward 2035. Established from the consolidation of the Institute of Chemistry–Materials and the Institute of New Technologies, IMBE aims to proactively research and master core technologies in the field of advanced materials for defense and security applications. The Institute focuses on the synthesis, design, and application of new materials with superior properties—such as lightweight structural composites, thermal-resistant alloys, nanomaterials, camouflage coatings, and bio-based functional substances. The research orientation aligns with the national strategy for science and technology in defense, emphasizing autonomy, sustainability, and integration of dual-use technologies.

Keywords: Advanced materials; Defense technology; Nanotechnology; Camouflage; Sustainability; Innovation.

1. INTRODUCTION

In the context of accelerating global technological competition and rapid development of military science, Vietnam's defense sector faces the strategic imperative of mastering critical technologies and ensuring technological sovereignty. The establishment of the Institute of Materials, Biology and Environment (IMBE) under the Academy of Military Science and Technology represents a proactive restructuring step toward focusing national efforts on research, innovation, and the application of advanced materials serving defense and security.

The Institute's formation was driven by the integration of two leading entities: the Institute of Chemistry–Materials and the Institute of New Technologies. This merger created a unified center capable of addressing cross-disciplinary challenges in materials science, biotechnology, and environmental protection for military purposes. Since its inception, IMBE has focused on leveraging the synergy of interdisciplinary research to develop advanced, cost-effective, and environmentally sustainable solutions for national defense.

2. RESEARCH RESULTS (2020–2025)

Building on its long-standing tradition of creativity, the Institute has proactively embraced modern technological trends to meet urgent defense and security demands. It has effectively fulfilled its advisory role and actively participated in numerous key scientific and technological (S&T) programs and projects under the Ministry of National Defense, including KC-T, KC-AT, KC-KT, KC-BM, and KC-TS projects, as well as the program on the development and application of biotechnology in the defense industry.

Additionally, the Institute has played a pivotal role in major environmental remediation missions, notably the dioxin decontamination project at Bien Hoa Airbase and waste management programs across the armed forces.

From 2020 to the present, the Institute has led 172 S&T projects at various levels, more than 100 of which have been completed, with many achieving excellent results and high applicability.

Over 90% of research products have been experimentally applied and deployed across military branches and services, including:

- Infrared camouflage uniforms;
- Demining protective suits;
- Bullet- and fragment-resistant helmets;
- Consumable materials for Kilo-636 submarines;
- Training torpedo batteries;
- Thermal batteries for anti-tank missile systems;
- MRD-1 and LRD-1 decontaminants;
- Field survival kits;
- Metal 3D printing materials, among others.

These products not only demonstrate robust R&D capabilities and direct usability but also enhance training effectiveness and combat readiness.

In addition to materials research, the Institute has achieved significant results in technical assurance and environmental treatment. It has mastered technologies for handling hazardous military waste such as chemical munitions, dioxin-contaminated soil and sediments, and developed field water purification systems and automatic emission and wastewater monitoring systems.

Moreover, the Institute has successfully transferred technologies to military units, such as electroplating lines for submarine repair, automatic chemical preservation systems, smart warehouses, and humidity-controlled storage bags for advanced weapon systems including P-28, Bastion, Accular, and T-90S tanks. These achievements have extended equipment service life, reduced environmental risks, and ensured readiness under harsh tropical conditions.

Collectively, these results affirm the Institute's comprehensive capacity in military S&T research, particularly in advanced materials, establishing a strong foundation for future development.

3. DEVELOPMENT ORIENTATION FOR 2025–2035

In alignment with global trends in materials science and the strategic requirements of modern armed forces, IMBE has defined a long-term roadmap emphasizing technological autonomy, innovation, and integration.

3.1. Short- to medium-term objectives (by 2030)

- Mastering 12–15 core fabrication technologies for advanced structural and functional materials, energy systems, and bio-derived materials supporting the production and maintenance of strategic military assets.
- Completing industrial-scale technologies for ready-to-eat military foods, plant propagation for island ecosystems, and systems for unexploded ordnance and chemical/dioxin treatment.
- Establishing continuous, automated environmental monitoring networks for military zones.

3.2. Long-term objectives (by 2035)

- Mastering deep-processing technologies for rare earths and radioactive elements, and the synthesis of next-generation alloys and composites for high-performance defense platforms.
- Advancing biotechnologies such as next-generation sequencing, AI-assisted bioinformatics, recombinant technologies, and microbial engineering for field health and biosurveillance.
- Developing AI-integrated environmental sensing systems for real-time detection and prediction of contamination events across military installations.

3.3. Key research areas

Looking toward 2035, IMBE will continue to pursue the strategic goal of advanced technologies across key research directions:

- **Intelligent and multifunctional materials:** Designing adaptive materials that integrate sensing, protection, and self-repair capabilities.
- **High-performance structural materials:** Developing ultra-light, ultra-strong composites and alloys resistant to corrosion and extreme environments.
- **Energy and power materials:** Enhancing battery technologies, fuel cells, and hybrid energy systems for autonomous defense platforms.
- **Nano- and bio-based materials:** Advancing controlled synthesis of metal nanoparticles, graphene derivatives, and bio-hybrid materials for medical and environmental defense applications.
- **Additive manufacturing and AI-driven design:** Employing 3D printing, computational modeling, and artificial intelligence to optimize performance and reduce R&D cycles.

IMBE will also strengthen international collaboration, technology transfer, and integration with national industrial partners to accelerate the transition of research results into defense production. The Institute envisions forming an **ecosystem of dual-use technologies**, where scientific innovation simultaneously supports defense readiness and civilian technological advancement.

Through proactive strategy, the Institute will position itself as a **core research hub** within the Ministry of National Defense, capable of contributing to Vietnam's long-term defense modernization and technological autonomy.

4. CONCLUSIONS

The Institute of Materials, Biology and Environment has made substantial contributions to the advancement of Vietnam's defense science and technology through proactive research and mastery of advanced material technologies. By combining interdisciplinary expertise in chemistry, materials science, biology, and environmental engineering, IMBE has developed practical, sustainable, and innovative solutions for modern defense applications.

The Institute's vision toward 2035 reaffirms its commitment to scientific excellence, innovation, and the creation of high-value defense technologies. Continued investment in human resources, infrastructure, and international cooperation will be essential for achieving technological independence and ensuring Vietnam's security in the era of intelligent warfare and global technological transformation.

TÓM TẮT

Chủ động nghiên cứu, làm chủ công nghệ chế tạo vật liệu mới phục vụ quốc phòng - an ninh

Bài báo trình bày các kết quả nghiên cứu và định hướng phát triển của Viện Vật liệu, Sinh học và Môi trường (Viện Khoa học và Công nghệ quân sự) trong giai đoạn 2020–2025, tầm nhìn đến năm 2035. Viện được hình thành trên cơ sở sáp nhập Viện Hóa học–Vật liệu và Viện Công nghệ Mới, với nhiệm vụ nghiên cứu chủ động, làm chủ các công nghệ vật liệu tiên tiến phục vụ quốc phòng, an ninh và phát triển bền vững. Các kết quả nổi bật gồm nghiên cứu chế tạo vật liệu ngụy trang đa phổ, pin nhiệt, hợp kim chịu nhiệt, vật liệu nano, vật liệu sinh học, và công nghệ xử lý môi trường quân sự. Định hướng phát triển đến năm 2035 là làm chủ 12–15 công nghệ lõi, hình thành hệ sinh thái công nghệ lưỡng dụng, góp phần hiện đại hóa nền khoa học và công nghệ quốc phòng Việt Nam.

Từ khóa: Vật liệu mới; Công nghệ quốc phòng; Công nghệ nano; Ngụy trang; Hợp kim bền.