附件 2

第九届中美工程前沿研讨会各议题中英文摘要

议题 1：碳捕集、利用与封存技术

碳捕集、利用与封存（CCUS）正从概念验证迈向大规模商业化解决方案。本次会议将重点关注两个视角，展示这一转型过程。第一方面聚焦地上范围内的碳捕集与资源转化技术，优先发展高效且具成本效益的创新材料与工艺；第二方面关注地下空间的碳封存与地质利用技术，强调可扩展、经济可行的新方法、新技术与新应用。需要突出传统技术的持续优化与突破性创新前沿技术的崛起，以及人工智能和信息技术为 CCUS 带来的变革性进步，这将为 CCUS 未来广泛部署提供有力支撑，并为实现全球碳中和目标作出重要贡献。

Session 1: CCUS

Carbon capture, utilization, and storage (CCUS) is transitioning from a proof-of-concept to large-scale, commercially viable solutions. This session will feature two perspectives that illustrate this transition. The first aspect focuses on carbon capture and resource conversion technologies within the terrestrial scope, prioritizing innovative materials and processes that are efficient and cost-effective. The second aspect centers on carbon storage and geo-utilization technologies in the subsurface realm, emphasizing novel methods, technologies, and applications that support scalability and cost-effectiveness. It is crucial to highlight both the continuous enhancement of traditional technologies and the rise of innovative breakthroughs, as well as the transformative advances driven by AI and information technologies in CCUS. This provides strong support for the broad implementation of

CCUS in the future and makes important contributions to reaching the global carbon neutrality goal.

议题 2：工程科学与传统医学的融合

工程科学与传统医学的融合运用先进的工程学方法，整合西方与东方医学的理论与实践，致力于开发创新、安全且高效的新型医疗解决方案。在生物医学工程、大数据与人工智能、高水平临床实践与患者护理以及制造工艺不断进步的推动下，传统医学在诊疗的客观性、可重复性及个性化方面取得了显著进展。

然而，这一融合领域仍存在诸多挑战。关键问题涵盖药材的质量控制、道地性、疗效稳定性及批次一致性。另一方面，传统诊断与治疗方法的智能化水平与客观化解读仍需进一步提高。技术瓶颈还包括数据采集标准化、算法可解释性、多模态数据融合，以及混合型医疗设备的监管协同。

展望未来，研发方向可聚焦于完善智能诊断工具、提升传感器精度与微型化、推进人工智能驱动的个性化方剂优化。值得关注的领域涉及生物材料与再生工程、生物合成技术、基因编辑、纳米医学与靶向递送、手术机器人、类器官与器官芯片模型系统，以及人工智能辅助的药物研发。这些创新将有机融合传统医学智慧与现代工程技术的严谨体系，助力构建更加可靠、普惠、整体观指导的医疗体系。

Session 2: Fusion of Engineering Science and Traditional Medicine

The integration of engineering science and traditional medicine applies advanced, engineering methods to both Western and Eastern Medicine approaches and practices, aiming to create innovative, safe, and highly

effective healthcare solutions. Significant progress has been achieved through advancements in biomedical engineering, big data and artificial intelligence (AI), high-quality clinical practices and patient care, as well as manufacturing advances, which together enhance the objectivity, reproducibility, and personalization of traditional medicine.

Nevertheless, this integration faces considerable challenges. Key issues include quality control, geographical authenticity of herbal medicines, and efficacy and batch consistency. Further development is also needed to enhance the intelligent and objective interpretation of traditional diagnostic and therapeutic methods. Technical barriers also include the standardization of data acquisition, algorithm interpretability, multi-modal data fusion, and regulatory alignment for hybrid medical devices.

Looking ahead, research and development can consider refining intelligent diagnostic tools, enhancing sensor accuracy and miniaturization, and advancing AI for personalized formulation optimization. Promising research directions include biomaterials and regenerative engineering, biosynthetic technology, gene editing, nanomedicine and targeted delivery, surgical robotics, organoid and organ-on-a-chip model systems, as well as AI-driven drug discovery. These innovations will help bridge ancient medicinal wisdom with modern engineering rigor, supporting the evolution of more reliable, accessible, and holistic healthcare systems.

议题 3：关键金属与材料：分离与提纯

新能源、电子信息等战略性产业的快速发展，正推动着对关键金属与材料前所未有的需求 。这包括能源相关金属（如锂、钴、镍），信息相关金属（如镓、锗、铟），以及多种稀有、稀散、稀土和贵

重元素 。然而，这些关键资源的高效分离与材料提纯，在经济可行性和环境可持续性方面仍面临着根本性挑战 。为提升这些资源的供应安全，必须发展关键金属选冶提取与高纯制备的理论、方法，及规模化推广潜力大且环境友好的技术。

本议题将重点展示新能源、电子信息等领域用关键金属与材料的最新研究进展，涵盖关键材料的分离与提纯，以及先进工艺的开发。报告将围绕富集、分离及资源循环基本原理与方法展开讨论，探讨降低能耗并减少废弃物的路径，关注系统与整体集成，包括资源循环、产业链和供应链安全战略等，为关键材料可持续供应提供路径。本议题将汇聚来自不同领域的青年工程师与学者，旨在推动跨学科交流与合作，共同探索应对关键金属与材料供应挑战的解决方案。

Session 3: Critical Metals and Materials: Separation and Purification

The rapid growth of strategic industries like new energy and electronic information is driving unprecedented demand for critical metals and materials. This includes energy-related metals (e.g., lithium, cobalt, nickel), information-related metals (e.g., gallium, germanium, indium), and a wide range of rare, dispersed, rare-earth, and precious elements. However, the efficient separation of these critical metal resources and the materials purification still face fundamental challenges of economic viability and environmental sustainability. To enhance the supply security of these resources, it is necessary to develop scalable and environmentally friendly technologies, focusing primarily on the theories and methods of metallurgical extraction and separation, while also considering downstream applications in the purification of critical metals. This session will highlight the latest

research advances on critical metals and materials for applications in new energy and electronic information. The topics will focus on the separation and purification of critical metals and the development of advanced separation materials and processes. The presentations will focus on the fundamental principles and methods of separation and resource recycling, while exploring pathways to reduce energy consumption and minimize waste. Emphasis will be placed on system-level integration, including resource recycling and industrial and supply chain security strategies, to provide new pathways for the sustainable supply of critical metals and materials. This session will bring together young engineers and scholars from diverse fields, promoting interdisciplinary discussion and collaboration to develop solutions for the challenges of critical metal and material supply.

议题 4：智能跨学科集成（I^3）能源系统协同设计

能源危机以及能源生产、转化与利用方式的低碳绿色转型持续构成全球性的工程挑战。交通电气化、电网现代化、储能技术应用及碳回收技术共同推动着可持续能源未来的实现。在已开发出高效、经济且可靠的能源系统基础上，我们当前必须设计更大规模的“系统之系统”集成架构，其中电气、机械、热力与化学等多学科领域需与先进智能技术协同创新。本期专题汇聚化石能源、新能源、电力系统及储能技术领域的专家学者，共同探讨前沿工程哲学与实践，以及多能源相互之间的协同利用与发展，旨在为我们预览未来十年综合能源系统的发展图景。

Session 4: Co-design of Intelligent Interdisciplinary and Integrated (I^3) Energy Systems

Energy crisis and greentransformation of energy generation, conversion, and usage continue to be a worldwide engineering challenge. Transportation electrification, grid modernization, energy storage utilization, and carbon recapture all contribute to a sustainable energy future. As we have developed some of the most efficient, cost-effective, and reliable energy systems, we now must design the larger-scaled integrated systems of systems, where interdisciplinary domains such as electrical, mechanical, thermal, and chemical must co-operate with advanced intelligence. In this session, we bring researchers from fossil energy, new energy, power systems, and energy storage backgrounds to discuss the frontier engineering philosophies and practices, particularly focusing on the synergistic utilization and development among multiple energy sources, that take us for a preview of the integrated energy systems in the next decade.