ANSO
Alliance of International Science Organizations

Highlight

September 2023
Issue.05

ANSO Highlight is to share the new ideas, methodologies, datasets and technologies of sustainability research by summarizing the latest progress and achievements of scientific projects funded by ANSO and ANSO partners. Through this publication, we would like to stimulate active collaboration and communication among ANSO members and partners.

International Collaborative Research Project

Research into Valorizing Atmospheric Carbon Dioxide via Its Sustainable Capture

PI Affiliation:
Royal Scientific Society of Jordan
Collaborating Organizations:
Mohammed VI Polytechnic University, Morocco;
Istanbul Technical University, Turkey;
ShanghaiTech University, China.

Summary

Our research activities focused on the synthesis of porous materials with a high affinity for CO2, particularly at very low pressure to enable carbon capture from the gas stream that mimics air concentration. Our initial search was focusing on the synthesis of polymeric and metal-organic framework (MOF) materials. However, our selection settled on porous polymers for many aspects such as ease of fabrication, low cost of production, scalability, and reasonable stability, because polymers normally can withstand humidity and acidic gases. Different polymers were synthesized and examined for surface area and CO2 uptake. Brunauer-Emmett-Teller (BET) surface area analysis measurement showed moderate surface areas of the synthesized polymers in the range of 106 to 420 $m^2.g^{-1}$ with types I and IV adsorption isotherms that prove material microporosity or mesoporosity of the resulting polymers. The synthesized microporous Polymer (MPP) showed significant performance for CO2 affinity represented by the relatively sharp CO2 uptake at low pressure (< 100 torr) compared to other reported and synthesized MPPs.

Period: January 2021-December 2023
PI: Bassem Al-Maythalony
Contact: bassem.maythalony@rss.jo

P2-P5

ANSO-CAS Joint Project

Cost-effective Preparation and Industrialization of Thermal Shielding Coatings for Tropical Industrial Factories

PI Affiliation:
Shanghai Institute of Ceramics, Chinese Academy of Sciences
Collaborating Organizations:
Philippine Economic Zone Authority (PEZA)
Hotta Palad Marble Corporation
Haotu Research and Development on Engineering
ShanghaiTech University, China.

Summary

Research background: Recognizing that environment and resources are the focus of China's foreign cooperation, this project is based on the advantages of new material technology of the Chinese Academy of Sciences and it is the foundation of cooperation with the Philippines, Thailand and other Southeast Asian "Belt and Road" countries. Tailings from the processing of rich coral reef and marble mineral resources from the Philippines and other countries are used to create energy-saving heat shielding coatings for buildings, tailored for the climate and economic conditions of Southeast Asian countries. The product will fill a gap in the Philippine market, and will be of interest to ANSO members.

Period: January 2021-December 2023
PI: CAO Xun
Contact: cxun@mail.sic.ac.cn

P6-P12

Research into Valorizing Atmospheric Carbon Dioxide via Its Sustainable Capture

Objectives

The development of advanced 'artificial trees' in the form of compact, energy-efficient carbon capture devices could have an immediate positive impact on decreasing carbon dioxide levels in the atmosphere and on purifying captured carbon dioxide for use as a high-quality product for different commercial applications.

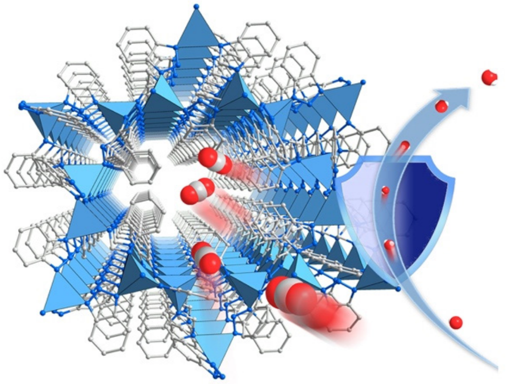
Research Contents

This project brings together researchers with unique expertise and experience from China, Turkey, Jordan, and Morocco to discover new solid adsorbents that can effectively act as 'artificial trees' by capturing carbon dioxide directly from air. These adsorbents are then re-shaped into different forms – from membranes to fixed beds – and integrated within a cost-efficient prototype device that is capable of capturing waste carbon dioxide directly from air for use in small-scale commercial applications.

Main Progress and Highlights

The research consortium has invented and synthesized a series of porous polymers, metal-organic frameworks (MOFs), and zeolitic imidazolate frameworks (ZIFs), characterized their structures on the atomic level through advanced techniques, and proven their ability to selectively capture carbon dioxide in the presence of other contaminant gases.

Pictured left to right: Dr Bassem Al-Maythalony (Royal Scientific Society, Jordan), Kyle E. Cordova ((Royal Scientific Society, Jordan), Dr Youssef Belmabkhout (University of Mohammad VI Polytechnic, Morocco), Dr Gamze Gur (Istanbul Technical University, Turkey), Dr Karim Adil (Le Mans University, France), and Dr Mert Gur (Istanbult Technical University, Turkey) at the first ANSO-sponsored international workshop and training meeting at Istanbul Technical University in Istanbul, Turkey in September 2021



A newly invented zeolitic imidazolate framework, termed ZIF-1001, that was demonstrated to successfully capture carbon dioxide from complex gas mixtures. A series of compounds with similar carbon-dioxide capturing properties will be reported in a high-impact, international journal in 2022.

The consortium has held one international workshop and training meeting at Istanbul Technical University in Istanbul, Turkey in September 2021 to strategically assess progress, carry out detailed data analysis, and promote communication, cooperation, and further collaboration in advancing the research program among the country partners.

Dr. Gamze Gur (Istanbul Technical University, Turkey) and her graduate students are demonstrating their research group's gas-phase, heterogeneous catalytic reactor for use during the second and third phase of the consortium's work on carbon dioxide utilization.

Future Plan

In 2022, the consortium focused on synthesizing porous materials for efficient carbon capture at low pressures. We successfully created new Zeolitic Imidazolate Frameworks (ZIFs), namely ZIF-1001 to ZIF-1004, and published their CO_2 uptake results in Angewandte Chemie. Additionally, we developed porous polymers with favorable characteristics like cost-effectiveness, scalability, and stability under humid conditions. Our progress involved synthesizing polymers at a larger scale and conducting analyses on their thermodynamic properties, pore size distribution, BET surface area, and dynamic capacity using a breakthrough device we built in-house. These advancements contribute to our ongoing search for effective carbon capture materials.

Publication and Intellectual Property

The results of the consortium's research work have led to three research articles published in high-impact, international journals:

1. Robust Barium Phosphonate Metal-Organic Frameworks Synthesized under Aqueous Conditions, ACS Materials Letters, 2021, 3, 1010-1015.
2. Control over Interpenetration for Boosting Methane Storage Capacity in Metal-Organic Frameworks, Journal of Materials Chemistry A, 2021, 9, 24857-24862.
3. Cross-linked, Porous Imidazolium-based Polys (Ionic Liquid) for CO_2 Capture and Utilisation, New Journal of Chemistry, 2021, 45, 16452-16460.
4. Zeolite NPO-Type Azolate Frameworks. Angewandte Chemie 2022, DOI: 10.1002/ange.202207467.
5. The Chemistry of Metal-Organic Frameworks with Face-Centered Cubic Topology, Coordination Chemistry Reviews, 2022, 468, 214644.
6. Back Cover: Zeolite NPO-Type Azolate Frameworks (Angew. Chem. Int. Ed. 39/2022)
7. Flexible Metal–Organic Frameworks as CO_2 Adsorbents en Route to Energy-Efficient Carbon Capture. Small Structures, 2022, 5, 2100209.
8. Covalent functionalization of ZIF-90 for improving mixed matrix membranes performance in CO2 separation, 2022, SSRN 4136344.
9. Environmentally Adaptive MOF-based Device Enables Continuous Self-Optimizing Atmospheric Water Harvesting, Nature Communications, 2022, 13, 4873.
10. Functionality-Induced Locking of Zeolitic Imidazolate Frameworks, Chemistry of Materials, 2023, DOI: 10.1021/acs.chemmater.2c02832.

One patent application has been submitted in China for the invention of zeolite NPO-type azolate frameworks and a second international patent application will be submitted once the Chinese patent is granted. The inventors include researchers from ShanghaiTech University, China and Royal Scientific Society, Jordan.

Principal Investigator

Bassem Al-Maythalony, Professor

Prof. Bassem received his Ph.D. in Chemistry in 2010 from King Fahd University of Petroleum and Minerals (KFUPM), Saudi Arabia, in the field of organometallic synthesis. After graduation, he moved on to work at King Abdullah University of Science and Technology (KAUST) as a Postdoctoral Fellow at the Center for Advanced Membranes and Porous Materials. During his post-doctoral period, he was actively involved in research projects in the field of Metal-Organic Frameworks (MOFs) development and MOF-based membranes. In 2014, Bassem joined King Fahd University of Petroleum and Minerals again as a Research Scientist under the Center for Technological Innovation - Carbon on Capture and Segregation (KACST-TIC-CCS). At King Fahd University of Petroleum and Minerals, Bassem focused on the synthesis of new materials, and on the exploration of different materials for practical applications. During his career at KFUPM, he got several funded projects in the fields of MOFs, membranes, and porous polymers. Bassem's scientific research output has exceeded 34 publications spread across journal papers, article reviews, patents, conference proceedings, and one book chapter in the field of inorganic, kinetic, and membrane chemistry. His research activities are appreciated by rebuttal publishers Nature, American Chemical Society (ACS), Elsevier, Wiley, and Royals Society of Chemistry (RSC). In December 2019, Bassem joined the Royal Scientific Society (RSS) in the research and development sector where he established the Advanced Research Center and led the Materials Discovery Unit concerned with the synthesis of new materials for practical applications.

Cost-effective Preparation and Industrialization of Thermal Shielding Coatings for Tropical Industrial Factories

Objectives

To fulfill specific requirements, several high-performance heat shield coatings were developed, and promoted in the Philippines and Thailand. An aim is to extend the product across tropical countries in the entire "Belt and Road" region, and so to promote energy-saving transformations in industrial processing

Research Contents

Research methods: Utilizing the properties of coral reef/marble tailings in the Philippines, this project prepares high-performance heat shielding coatings through research methods such as composition analysis, formulation design and surface modification.

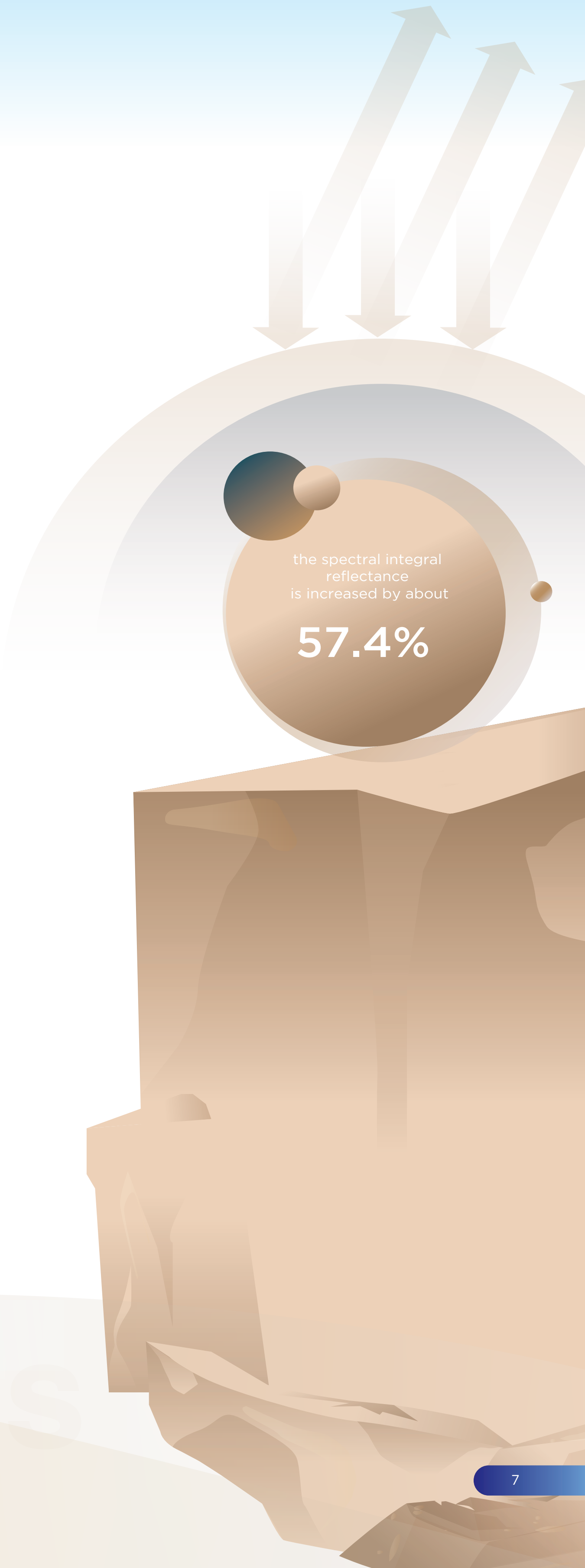
Technical route: Utilize the abundant local resources of ore tailings in the Philippines, through broad-spectrum heat shielding formula design, solid particle size control, surface modification and dispersion, as well as coating processing, rust construction, anti-corrosion services and other technological breakthroughs, more than two types of high-performance heat shielding coatings have been developed.

Cooperation mechanism: Prepare roof heat shielding coatings for industrial buildings, and promote sales after completing field experiments in the Philippines and Thailand to fill a gap in the local market.

Main Progress and Highlights

Characterization of performance

The coating products have been tested by a third-party authoritative organization (as shown in Figure 1), which proves that they have excellent performance. The coated sample has good sunlight reflection ability, and the spectral integral reflectance is increased by about 57.4% compared with the blank substrate. In order to expand ANSO's local influence, it is planned to design and print the logo and product model number (as shown in Figure 2) with "ANSO" and "SICCAS" on the delivered products (primer + topcoat), so as to improve the quality of the products. It is good to carry out promotion and publicity under the guidance of ANSO.

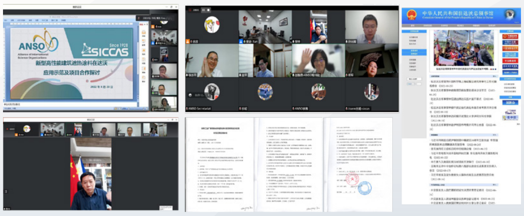


Domestic pilot test

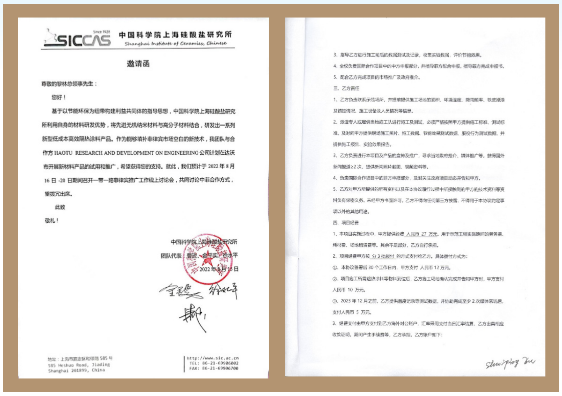
At present a cooperation agreement has been reached with a partner, Guohua Construction Co., Ltd. The partner can provide 5000 m^2 of color steel plates. This project has completed the preparation of coatings for a 5000 m^2 domestic industrial plant, including primer and topcoat, a total of 3 tons of new heat shielding coatings (Figure 4).

Foreign demonstration sites

The demonstration project will be established in Davao, Philippines, and an agreement will be signed with HAOTU RESEARCH AND DEVELOPMENT ON ENGINEERING on cooperation in the establishment of the demonstration project. The Consulate General of the China in Davao City and schools within the jurisdiction of Davao City will be taken as demonstration sites, and priority will be given to energy-saving transformation. Figure 7 shows a video conference with the Consulate General of the China in Davao, Philippines, to demonstrate the application of high-performance building thermal control technology. The conference invited Li Lin, Consul General of the People's Republic of China in Davao, Zhao Minyan, ANSO Project Management Office, and Philippine cooperation companies. The conference carried out news publicity on the homepage of the official website of the Consulate General in Davao. The design and implementation of the demonstration project will help solve practical problems such as overheating of local buildings, and play a good role in promoting the construction of the "the Belt and Road" between China and the Philippines.



Exploring the Application Demonstration of High Performance Building Thermal Control Technology with the Philippine Consulate in Davao



中国科学院上海硅酸盐研究所
Shanghai Institute of Ceramics, Chinese

邀请函

尊敬的黎林总领事先生：

您好！

基于以节能环保为纽带构建利益共同体的指导思想，中国科学院上海硅酸盐研究所利用自身的材料研发优势，将先进无机纳米材料与高分子材料结合，研发出一系列新型低成本高效隔热涂料产品。作为能够填补菲律宾市场空白的新技术，我团队与合作方 HAOTU RESEARCH AND DEVELOPMENT ON ENGINEERING 公司计划在达沃市开展新材料产品的试用和推广，希望获得您的支持。就此，我们预计于 2022 年 8 月 16 日 -20 日期间召开一带一路菲律宾推广工作线上讨论会，共同讨论中菲合作方式，望拨冗出席。

此致

敬礼！

中国科学院上海硅酸盐研究所

团队代表：曹逊、金平实、徐水平

2022 年 8 月 15 日

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3、指导乙方进行施工前后的数据测试及记录，收集实验数据，评价节能效果。

4、全权负责国际合作项目中的中方申报部分，并指导菲方配合申报，指导菲方完成申报书。

5、配合乙方完成项目的市场推广及政府推介。

三、乙方责任

1、乙方负责联系示范场所，并提前提供施工场地的面积、环境温度、降雨频率、铁皮掉漆及锈蚀情况、施工设备及人员情况等信息。

2、派遣专人或雇佣当地施工队进行施工及测试，必须严格按照甲方提供施工标准、测试标准，及时向甲方提供现场施工照片、施工数据、节能效果测试数据、服役行为测试数据，并提供施工报告、实验效果报告。

3、乙方负责进行本项目及产品的宣传及推广，寻求当地政府推介、媒体推广等，获得国外新闻报道≥2 次，提供新闻照片截图、视频资料等。

4、负责国际合作项目中的菲方申报部分，及时关注政府项目动态并告知甲方。

5、乙方对甲方所提供的所有资料以及在本协议履行过程中所接触到的甲方的技术资料等资料负有保密义务，未经甲方书面许可，乙方不得向任何第三方披露，不得用于本协议约定事项以外的其他用途。

四、项目经费

1、本项目实施过程中，甲方提供经费 人民币 27 万元，用于示范工程实施期间的劳务费、耗材费、场地租赁费等。其余不足部分，乙方自行承担。

2、项目经费甲方按 分 3 批拨付 的方式支付给乙方。具体拨付方式为：

①、本协议签署后 30 个工作日内，甲方支付 人民币 12 万元。

②、项目施工所需遮热涂料等物料到位后，乙方施工场地确认完成并告知甲方时，甲方支付人民币 10 万元。

③、2023 年 12 月之前，乙方提供温度记录等测试数据，并协助完成至少 2 次媒体采访后，支付人民币 5 万元。

3、经费支付由甲方支付到乙方海外对公账户，汇率采用支付当日汇率结算，乙方出具相应收款证明。期间产生手续费等，乙方承担。乙方账户如下：

Future Plan

- In the next step, field tests will be conducted at the construction sites of domestic and foreign demonstration sites, and the heat shielding effect of the coating products will be verified.
- It is planned to use its existing 1,000-square-meter factory building through local investment in the Philippines to build a production base according to the formula of the project technology.
- Meet the needs of related companies in South Asia and Southeast Asia like those in the Philippines and Thailand, and conduct sales to achieve the planned goal of promoting the use of high-performance heat shielding coatings in Southeast Asia.

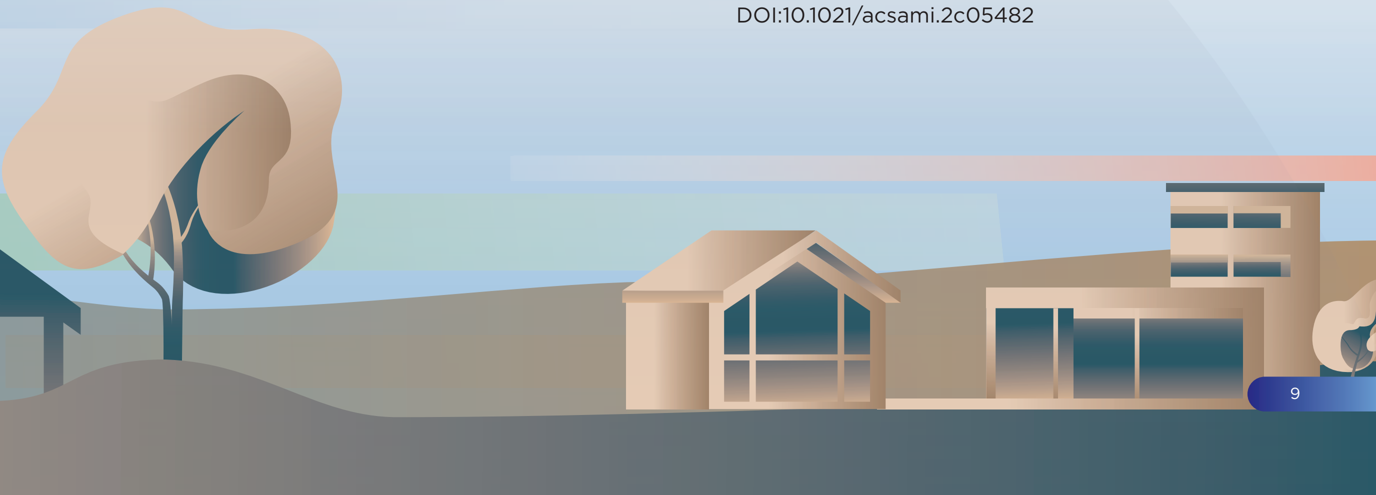
Highlight

- This project develops a series of high-performance heat shielding coatings according to the actual situation of the place of use. The products and technologies are mainly promoted in the Philippines and Thailand.
- Complete the establishment of a 2200m^2 foreign demonstration site, and carry out energy-saving renovations for industrial plants, producing a total of 2.34 tons of transport coating products.
- Complete the coating preparation and transportation of the 5000 m^2 domestic industrial plant, send the products to the Philippines through international logistics, and conduct local construction and field verification.

Publication and Intellectual Property

Published 2 papers in ACS Appl. Mater. Interfaces (zone 1, IF=10.383) and Chemical Engineering Journal (zone 1, IF=16.744), and ANSO marked the first place in the paper.

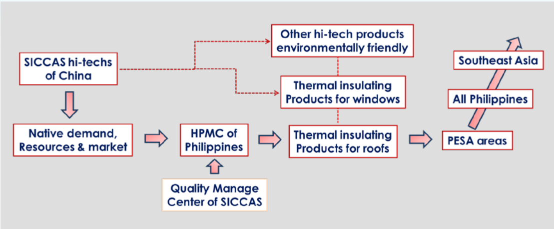
- Z. Li, S. Zhao, Z. Shao, H. Jia, A. Huang, P. Jin, X. Cao,* Deterioration mechanism of vanadium dioxide smart coatings during natural aging: Uncovering the role of water, Chemical Engineering Journal, 447 (2022) 137556. DOI: 10.1016/j.cej.2022.137556
- C. Cao, H. Bin, G. Tu, X. Ji, Z. Li, F. Xu, T. Chang, P. Jin, X. Cao,* Sputtering Flexible VO2 Films for Effective Thermal Modulation, ACS Applied Materials & Interfaces, 14(24) (2022) 28105-28113. DOI:10.1021/acsami.2c05482



Principal Investigator

CAO Xun, Professor

Prof. CAO Xun obtained his Ph.D. from Shanghai Institute of Ceramics, Chinese Academy of Sciences (SICCAS), China, in 2010. He joined University of California, Berkeley in 2015 as a visiting research fellow. In 2016, he returned SICCAS working as a full professor and Deputy Director of Ancient Ceramics Research Center, as well as Head of Research Group of Smart Materials for Energy Modulation. His research interests include processing and characterization of functional oxides films, chromogenic materials and advanced coatings for the applications of energy-efficient project. Prof. Cao has published over 100 papers (containing Nature Electronics, Nature Communications etc.), 4 book chapters, and made more than 30 patents. He has presided over 15 national, provincial and ministerial projects, including National Key Research & Development Program and National Natural Science Foundation of China et. al. In 2022, he was awarded as National High-Level Young Talents and Excellent Member of the Youth Promotion Association of the Chinese Academy of Sciences. In 2023, he was elected as Fellow of the Royal Society of Chemistry (FRSC).

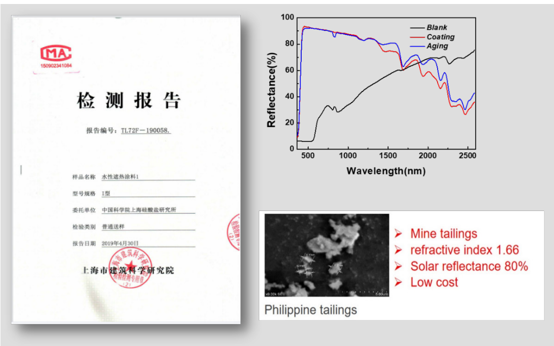


Future development plan

Photos of 2200 m^2 color steel plate and coating products in the Philippines

Coating product transportation route

Photos of 5000 m2 factory, coating products and on-site construction



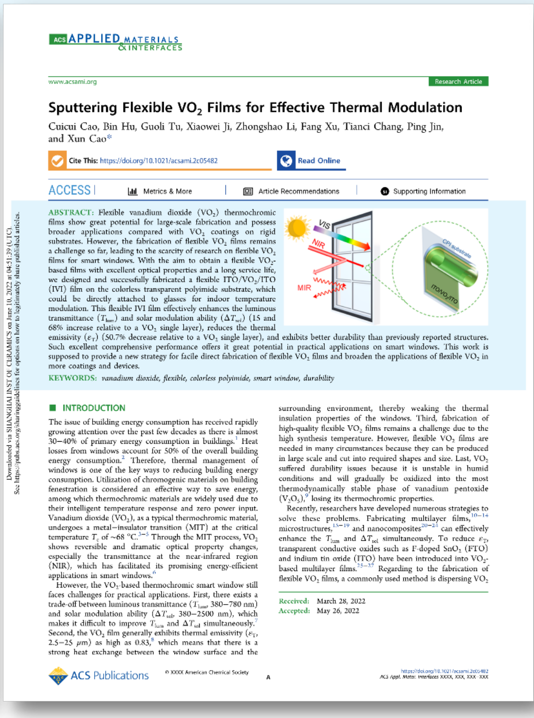
Third-party inspection report and performance test

The physical picture, logo and model of the new heat shielding coating product


Chemical Engineering Journal 447 (2022) 137556

Deterioration mechanism of vanadium dioxide smart coatings during natural aging: Uncovering the role of water

Zhongshao Li, Shuwen Zhao, Zewei Shao, Hanxiang Jia, Aibin Huang, Ping Jin, Xun Cao


ACS APPLIED MATERIALS & INTERFACES

Sputtering Flexible VO_2 Films for Effective Thermal Modulation

Cuicui Cao, Bin Hu, Guoli Tu, Xiaowei Ji, Zhongshao Li, Fang Xu, Tianci Chang, Ping Jin, and Xun Cao

Cite This: https://doi.org/10.1021/acsami.2c05482

Project article results

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