DOI: 10.1049/hve2.12243

国家电网 STATE GRID 中国电力科学研究院有限公司 CHINA ELECTRIC POWER RESEARCH INSTITUTE
The Institution of Engineering and Technology
WILEY

GUEST EDITORIAL

Advanced insulating materials contributing to "carbon neutrality": Opportunities, issues and challenges

The vision of 2050 worldwide carbon-neutral ignites a revolution in all industries. Enormous innovations in both electrical power equipment and electrified transportation assets are shaping our future energy structure. Insulating materials, as the core element of energy infrastructure, are facing unprecedented challenges that stand in the pathways to global carbon neutrality. However, researchers from both academic institutions and industrial sections are working to turn the challenges into opportunities.

This special issue is put forward to envision the challenges of future electrical equipment and transportation electrification in the context of policies towards carbon neutrality goals. It also brings the focus on future research directions and opportunities of novel insulating materials that play a key role in realising the carbon-neutral vision.

Four articles comprise this special issue, including two review papers and two technical papers. A brief introduction of each paper is presented as follows:

1 | INSULATING MATERIALS FOR REALISING CARBON NEUTRALITY: OPPORTUNITIES, REMAINING ISSUES AND CHALLENGES

This feature article presents the joint work of 28 experts with 23 affiliations from six countries. In this article, the goal of carbon neutrality and the urgent need for innovation in electric power equipment and electrification assets are discussed. The engineering challenges constrained by the insulation system in future electric power equipment/devices and electrified transportation assets are also investigated. Insulating materials, including intelligent insulating material, high thermal conductivity insulating material, high-energy storage density insulating material, extreme environment resistant insulating material, and environmental-friendly insulating material, are categorised with their scientific characteristics, opportunities and challenges. In-depth discussion of how these insulation materials contribute to our carbon neutral goal is presented.

2 | HIGH VOLTAGE DIRECT CURRENT TRANSMISSION CABLES TO HELP DECARBONISATION IN EUROPE: RECENT ACHIEVEMENTS AND ISSUES

Written by Professor Giovanni Mazzanti, IEEE Fellow, at University of Bologna, this paper tackles the problem the High voltage direct current (HVDC) cable faces to decarbonisation. With particular reference to the situation in Europe, the author presents a few simple calculations showing, in general terms, the quantitative contribution provided by HVDC cable systems to decarbonisation. The major issues towards long-lasting and reliable HVDC cable systems are summarised briefly, in the way of brevity on the influence of the main HVDC cable technologies, of cable-laying environment, and of duty service. Some hints are also provided at the opportunities given by multiterminal HVDC systems.

3 | DESIGNING HVDC GIS/GIL SPACER TO SUPPRESS CHARGE ACCUMULATION

This is a technical paper contributed by Professor Jinliang He, IEEE Fellow, and his team at Tsinghua University. In this paper, a design method of the DC spacer is proposed, and a spacer prototype is prepared and evaluated both by simulation and type test. The DC withstand voltage test and polarity reversal test are performed using the new DC spacer compared with a commercialised 220 kV alternating current (AC) spacer. The simulation results indicate that the surface electric field and surface charge of the DC spacer are lower than those of the AC spacer under DC voltage. The test results verify that the surface flashover voltage of this DC spacer is higher than that of the AC spacer. The potential applications of the spacer design for HVDC are discussed.

4 | AGEING EVALUATION OF CABLE INSULATIONS SUBJECTED TO RADIATION AGEING: APPLICATION OF PRINCIPAL COMPONENT ANALYSES TO FTIR AND DIELECTRIC SPECTROSCOPY

This is a technical paper presenting the joint work led by Dr. Simone Vincenzo Suraci at the University of Bologna and Professor Nathalie Dupuy at Aix-Marseille Université. The evolution of properties of XLPE-based insulating materials under radio-chemical ageing conditions is presented and discussed. The results show that phenol-based antioxidants are found to be the most efficient in terms of protection against oxidation. On the contrary, flame retardants are concluded not to have any impact on the material ageing. The results confirm the relevance of this analysis to understanding the impact of irradiation on the chemical and functional properties of the polymer materials studied.

It has to be admitted that the scope of this special issue is of course far from exhaustive. Due to space limitations and the limited ability of the editor team, there are still many important studies that are not included. Nevertheless, we do hope that the information conveyed in this special issue can provide reference for researchers in the field of electric equipment and insulating materials, especially in selecting research topics and breakthrough points so as to contribute to the shared goal of carbon neutrality in the near future.

ACKNOWLEDGEMENTS

We would like to thank all the authors and reviewers who support the work of this special issue. As well, we would like to thank Professor Shengtao Li for providing valuable comments. The contributions from the editors in Editorial Office of High Voltage, in particular Dr. Zheng Xiao, Miss Yangyang Yu, and Miss Muchen Ran, are highly appreciated.

Chuanyang Li[1]
Yunlong Zi[2]
Yang Cao[3]
Giovanni Mazzanti[4]
Davide Fabiani[4]
Di Zhang[5]
Yunqi Xing[6]
Jinliang He[1]

[1]*State Key Laboratory of Power System, Department of Electrical Engineering, Tsinghua University, Beijing, 100084, China*
[2]*Department of Mechanical and Aerospace Engineering, The Hong Kong University of Science and Technology, Clear Water Bay, Hong Kong SAR, China*
[3]*Electrical and Computer Engineering, University of Connecticut, 371 Fairfield Way, Storrs, CT 06269, USA*
[4]*Department Electrical, Electronic and Information Engineering, University of Bologna, Bologna 40136, Italy*
[5]*Electrical and Computer Engineering Department, Naval Postgraduate School, 1 University Circle, Monterey, CA 93943, USA*
[6]*State Key Laboratory of Reliability and Intelligence of Electrical Equipment, Hebei University of Technology, Tianjin, 300131, China*

Correspondence
Chuanyang Li, State Key Laboratory of Power System, Department of Electrical Engineering, Tsinghua University, Beijing, 100084, China.
Email: chuanyang_li@tsinghua.edu.cn

AUTHOR BIOGRAPHIES

Chuanyang Li, PhD, assistant researcher at Tsinghua University. His research interest focusses on advanced insulation technology for the future electric power system and electrified transportation asset.

Yunlong Zi, PhD, associate professor at the Hong Kong University of Science and Technology (Guangzhou). His research areas include fundamental study and novel design of triboelectric nanogenerators, synthesis and characterisation of nanomaterials, and piezotronics and nanoelectronics.

Yang Cao, PhD, professor at University of Connecticut. His research interests are in the physics of materials under extremely high field and the development of new dielectric materials, particularly the polymeric nanostructured materials, for energy efficient power conversion and renewables integrations, as well as for novel medical diagnostic imaging devices.

Giovanni Mazzanti, PhD, professor at University of Bologna, IEEE Fellow. His interests are life modelling, reliability and diagnostics of HV insulation, power quality, renewables and human exposure to electromagnetic fields.

Davide Fabiani, PhD, professor at University of Bologna. His research interests include development, characterisation, and diagnosis of electrical insulation systems for applications in electrical and electronic apparatus.

Di Zhang, PhD, professor in the Naval Postgraduate School. His research interests include modelling and design of medium to high voltage power converters, SiC-based high-performance power conversion, and power conversion system for grid, renewable, and aviation.

Yunqi Xing, PhD, professor at Hefei University of Technology. His research interests are new dielectric materials, extreme environment insulation, and the reliability improvement technology of electrical equipment.

Jinliang He, PhD, professor at Tsinghua University, IEEE Fellow, IET Fellow. His research focusses on advanced power transmission technology, grounding technology, lightning protection, advanced dielectric materials and sensing technology.