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INSTITUT INTERNATIONAL DU FROID  
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JSRAE

## Keynote Lecture 8

### Research and application on the HFO refrigerants

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Vice president of Tianjin Association of Refrigeration



Zhao Yang is a Professor of Tianjin University (Founded in 1895 as Peiyang University). She has also been appointed as a vice president of the Tianjin Association of Refrigeration (TAR), the director of the Chinese Association of Refrigeration (CAR) and the expert of the Working Party on Refrigerant System Safety in International Institute of Refrigeration (IIR).

Prof. Yang's team has been engaged in the field of energy conservation, environmental protection of refrigeration systems, especially in the substitution for HCFCs and HFCs by new environmentally friendly refrigerants used in advanced refrigeration, air conditioning and heat pump for many years. In recent years, her team has begun to focus on thermodynamic properties and combustion characteristics of the new refrigerants. As the leader of advanced refrigeration laboratory, she has completed more than 60 projects, such as national projects and enterprise technology development projects, published 5 academic books and more than 100 papers in high impact international journals, which have been quoted by other researchers for more than 2500 times. She has also obtained more than 60 invention patents, and won 6 scientific awards. As a prominent woman in industry, her story is published on the website of the United Nations Environment Programme (UNEP).

## Research and application on the HFO refrigerants

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### ABSTRACT

As the largest developing country in the world, China is expected to achieve the world's largest carbon intensity reduction. According to the Kigali amendment schedule, the use of high GWP refrigerants will be frozen by 2024. The refrigeration industry faces many technical challenges. At present, the country and related industries are strengthening the control of non-carbon dioxide greenhouse gases such as HFCs, striving to achieve the transition from peak carbon dioxide emissions to carbon neutrality in the shortest time in global history.

Research for the new generation refrigerants with low greenhouse effect has become an urgent task. HFOs have lower greenhouse effect and may be used as long-term substitutes from the perspective of environmental protection. For example, HFO1234yf is mainly used to replace R134a in automotive air conditioning and residential heat pump water heater. R1234ze(E) may be used in centrifugal water chiller, medium high temperature heat pump and water heater. R1233zd(E) may be used in double frequency conversion centrifugal chiller, low temperature heat recovery system, high temperature heat pump, etc. As the main low GWP substitutes of HFCs, HFOs still have some key problems to be solved, such as flammability, miscibility, compatibility and thermodynamic performance.

With the upgrade of the technical research reports and safety standards for the new generation refrigerants, the flammable refrigerants will become a new application trend in the future. Due to the relaxation of the use standard of flammable refrigerants, they have been rapidly pushed into the market, the accident risk of leakage and explosion cannot be neglected. So the research of the flammability characteristics for the new generation alternatives is urgent. Firstly, it is necessary to investigate the combustion characteristics and mechanism of HFO refrigerants. The flammability characteristics of flammable refrigerants are affected by many factors, such as temperature, humidity, pressure, ignition source. The combustion reaction path of HFOs can be predicted by analysing the energy barrier, reaction heat, and the main combustion products. Secondly, it is necessary to study the inerting mechanism of combustion suppression for flammable refrigerants further. Finally, the risk identification, early warning and protection mechanism of HFO refrigerants should be clarified. Leakage risks exist in the whole life cycle of refrigeration equipment: production, transportation, parts manufacturing, operation, maintenance, etc. Risk assessment of flammable refrigerants must take the hazards of the combustion and decomposition products into consideration. Therefore, it is very important to establish risk assessment model and safety criterion with multiple characteristic parameters.

At present, the research on HFOs mainly focuses on the basic thermodynamic properties and system cycle characteristics, but the interaction between HFOs and lubricating oils is not very clear. It is necessary to emphasize the research on the miscibility, solubility, viscosity and material compatibility of HFOs/lubricating oil mixture. The miscibility of refrigerant with lubricating oil is the most important test in evaluating the ability of the lubricating oil to move through the system back to the compressor. It is mainly evaluated by measuring the critical miscibility temperature of refrigerant with lubricating oil. The solubility, viscosity and material compatibility of refrigerant with lubricating oil are mainly used to evaluate the interaction between refrigerant and lubricating oil in the compressor. As a new generation of low-GWP refrigerants, HFOs' interaction with lubricating oil is essential to maintain the reliability and efficiency of the system.