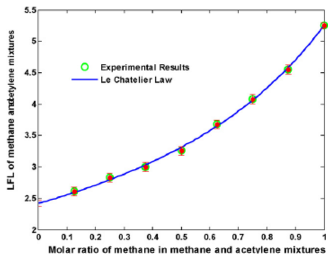
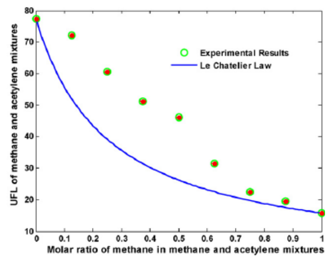
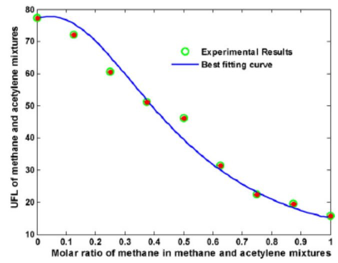
Flammability Limits of Fuel Mixtures

I: Modification of Le Chatelier's Mixing Rule

Le Chatelier's mixing rule is a popularly used empirical approach to estimate LFL and UFL of fuel mixtures. We conducted experiments to verify its application capacity. Generally, it works well when applied to fuel mixture LFL. However, its prediction on UFL becomes weak, especially to fuel mixture containing unsaturated components. Modification of Le Chatelier's rule was proposed for accurate fuel mixture UFL.

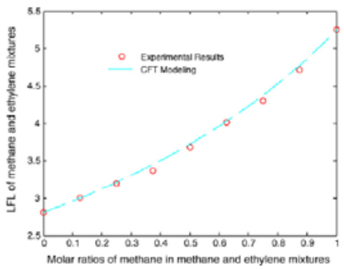


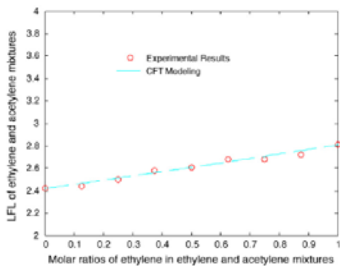


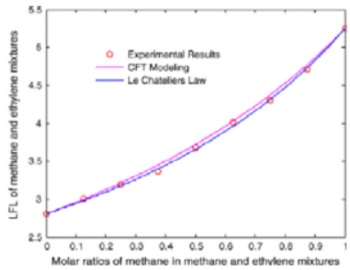


II: Flammability Limit Prediction Using CFT Modeling

Different from calculated adiabatic flame temperature (CAFT) modeling, heat loss is considered in the proposed calculated flame temperature (CFT) modeling, because heat loss can affect experimental flammability limits and it becomes indispensable when apparatus quenching effect becomes significant. For accurate purpose, in CFT modeling, flame temperature is specified for each pure component, and fuel mixture flame temperature is calculated based on the principle of energy conservation. Consistence between the CFT modeling predictions and experimental results indicates a theoretical explanation of fuel mixture flammability limit, as well as a new way (besides Le Chatelier's mixing rule) using CFT modeling to estimate fuel mixture flammability limits.

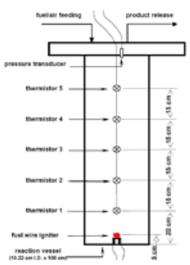






III: Inert gas dilution effect on UFL/LFL of fuel mixtures

Fire suppression using inert gases is a significant safety issue in chemical process industry. So far, most of the previous research in this field has focused on pure fuels. In this research, we measured the LFL/UFL of fuel mixtures with addition of inert gases at different concentrations. Then we quantified the inert gas dilution effect on fuel mixture LFL/UFL by introducing the parameter of inert gas dilution coefficient, γ. General principle of inert gas dilution effect on fuel mixture is that the LFL/UFL of fuel mixture can be linearly relates to added inert gas concentration with some exceptions, e. g, hydrocarbon mixtures containing ethylene.



Pure fuels	γ
CH_4	0.0049
C_2H_4	0.0033
C_2H_6	0.0034
C_3H_6	0.0044
C_3H_8	0.0048
C_4H_{10}	0.0050