CURRICULUM VITAE

Department and Graduate School of Safety, Health, and Environmental Engineering
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Academic Qualification

- **Ph.D**., Department of Chemical Engineering, University of Missouri-Rolla (UMR), Rolla, Missouri, USA (1990)
- **MS**, Department of Chemical Engineering, UMR, Rolla, Missouri, USA (1987)
- **BS**, Department of Chemical Engineering, Tunghai University, Taichung, Taiwan, Republic of China (1982)

Academic and Research Experience

- **Academic Vice President** (08/2017–07/2019), National Yunlin University of Science and Technology (YunTech).
- **Distinguished Chair Professor** (08/2016–Present)
- **Distinguished Professor** (08/2011–07/2016)

- **Professor** (02/2003–07/2011)

- **Associate Professor** (08/1995–01/2003), Process Safety and Disaster Prevention Laboratory, Department of Safety, Health, and Environmental Engineering, National Yunlin University of Science and Technology (YunTech), Douliou, Yunlin, Taiwan, ROC.

Self-introduction

Currently, I am serving as Distinguished Chair Professor of YunTech with the prime focus of initiating the prodigious impulse in the field of process safety. I have been successful so far in doing so, by establishing a state-of-the-art laboratory facility exclusively for the process safety and disaster prevention (PS&DPL), first-of-its-kind in Taiwan. PS&DPL research activities include loss prevention, thermokinetic hazard analysis, runaway reaction analysis, combustible gas or dust explosion analysis, risk assessment, and process-safety-related aspects. The PS&DPL core research team constantly figures out the solutions to the critical challenges arising in the real life process industries under my supervision. The team is committed in anticipating the possible catastrophic events that may arise due to the lack of safety issues, and replicate the instances in the laboratory scale and suggest the suitable solutions. The worthiness of my lab findings especially process safety and disaster prevention were documented through publishing 342 peer-reviewed scientific aspects in reputed science journals since 2001.

Coming to the rewards and recognitions, in the past decade I have received North American Thermal Analysis Society (NATAS) Fellow Award in 2011, and was elected as an American Institute of Chemical Engineers Fellow in 2016. In 2017, our continuous contributions were recognized by the NATAS Mettler-Toledo Award, the most prestigious in the field of Thermal Analysis in North American since 1968.

Looking towards the industrial achievements, I have served as the one of the investigating team for the one Taiwan's awful industrial disaster (Kaohsiung gas explosion, 2014). I also have been deeply concerned by a series of disastrous accidents that have occurred in chemical plants; these were adverse economic disasters for chemical industry development in Taiwan and engendered social anxiety. I joined the investigation team for the underground pipeline explosion that occurred in August 2014 in Kaohsiung, Taiwan, which is a well-known disaster. Moreover, since 2005, I have been an Advisory Board Member of Fire Accident Investigation in (1) the National Fire Agency, Ministry of the Interior,

(2) Taichung City, and (3) the Yunlin County Fire-Fighting Department. In 2015, I have been recognized as the only scholar in the field of chemical process safety to be one of the members at the Environmental Impact Assessment (EIA) Committee, accredited by Environmental Protection Administration of the Executive Yuan, Taiwan. To date, I have reviewed 500+ EIA reports and attended more than 100 EIA meetings.

About academic dedication, I have served as an editorial board member to renowned scientific journals, such as Process Safety Progress (SCI), Journal of Safety Research (SSCI), Journal of Loss Prevention in the Process Industries (SCI), and as an associate editor for the Journal of Thermal Analysis and Calorimetry (SCI) during 2009–2010 and 2018–2020.

Activities

- **Feng Tay Distinguished Professor**, National Yunlin University of Science and Technology (YunTech), Douliou, Yunlin, Taiwan, ROC. (02/2018–Present)
- **Academic Vice President,** YunTech, Douliou, Yunlin, Taiwan, ROC. (08/2017–07/2019)
- **Curator**, YunTech, Library, Douliou, Yunlin, Taiwan, ROC. (02/2017–07/2018)
- **President**, Institute of Industrial Safety and Disaster Prevention of Taiwan, ROC. (08/2016–Present)
- **President**, Association of Tunghai University Alumni in Yunlin, Taiwan, ROC. (01/2015–10/2016)
- **Adjunct Professor**, China Medical University, Taichung, Taiwan, ROC. (12/2014–Present)
- **Standing Director,** Industrial Safety and Health Association of the ROC. (07/2020–Present)
- **Director,** (1) Center for Process Safety and Industrial Disaster Prevention, Taiwan, ROC. (05/2015–Present), (2) Gui Zong Social Welfare Charity and Education Foundation, Chayi, Taiwan, ROC. (10/2013–Present), (3) Center for Industry-Academia Collaboration, Ministry of Education, Taiwan, ROC. (08/2005–07/2009; 08/2010–08/2014)
- **Associate Dean,** Office of Research and Development, YunTech. (08/2009–07/2010)
- **Fellow,** (1) American Institute of Chemical Engineers (AIChE), USA. (02/2016–

Present), (2) North American Thermal Analysis Society (NATAS), USA. (05/2011–Present), (3) Institution of Engineering and Technology (IET), UK. (04/2018–Present), (4) Royal Society of Chemistry (RSC), UK. (07/2018–Present). (5) Institute of Industrial Safety and Disaster Prevention of Taiwan, ROC. (11/2018–Present)

- **Member,** AIChE Fellow Council, USA. (09/2016–08/2019)
- **Chairman,** Pressure Vessel Association of ROC (PVA), Taiwan, ROC. (07/2008–04/2013)
- **Senior Supervisor/Technical Adviser,** PVA, Tainan, Taiwan, ROC. (05/2013–Present)
- **Advisor,** AIChE Student Chapter, USA. (03/2015–Present)
- **Advisor,** Yunlin County Government, Yunlin, Taiwan, ROC. (04/2019–12/2022)
- **Convener,** Fellow nomination for AIChE in Far East area. (01/2017–Present)
- **EIA Board Member,** (1) Environmental Protection Administration, Executive Yuan, Taiwan, ROC. (08/2015–07/2019), (2) Taichung City, Taiwan, ROC. (07/2017–06/2019), (3) Changhua County, Taiwan, ROC. (11/2007–10/2013), and (4) Yunlin County, Taiwan, ROC. (03/2018–03/2020)
- **Examination Board Member,** Ministry of Examination, Executive Yuan, Taiwan, ROC. (12/2007; 05/2013; 11/2016)
- **Section Convener,** Ministry of Examination, Executive Yuan, Taiwan, ROC. (05/2019)
- **Proposition Board Member,** Ministry of Examination, Executive Yuan, Taiwan,

ROC. (12/2007; 04/2013; 11/2015; 11/2016; 08/2017; 11/2018)

- **Reexamine Commissioner,** Environmental Engineering Program, National Science Council (NSC), Executive Yuan, Taiwan, ROC. (2007–2010)
- **Advisory Board Member,** Fire Accident Investigation, (1) National Fire Administration; Ministry of Interior, Executive Yuan, Taipei, Taiwan, ROC. (03/2009–Present), (2) Taichung City Fire-Fighting Department, Taichung, Taiwan, ROC. (03/2009–Present), and (3) Yunlin County Fire-Fighting Department, Yunlin County, Taiwan, ROC. (03/2005–Present)
- **Process Engineer,** Process Department, Bechtel Corporation, Houston, Texas, USA. (1990–1994)
- **Program Organizer,** The 1st & 3rd Forum on Cross-strait of Industrial Security, Yunlin, Taiwan, ROC. (01/2015 & 01/2016)
- **Program Organizer,** 1st International Conference on Loss Prevention, Process Safety, and Thermal Analysis in Chemical and Coal industries (LPPSTA 2019)", Douliou, Yunlin, Taiwan, ROC. November 24–27, 2019.

Research interest

- Process Safety Design/Management; Runaway Reaction; Emergency Relief System Design; Fire and Explosion Prevention; Chemical Emergency Response Technique; Thermal Stability Analysis for Reactive Materials; Chemical Process Quantitative Risk Assessment; Risk-based Inspection; Mechanical Integrity; Waste and Wastewater Recovery and Recycle; Advanced Loss Prevention in the Process Industries by Artificial Intelligence; Coal Spontaneous Combustion.

Editorship of Scientific Journals

- **Associate Editor,** *Journal of Thermal Analysis and Calorimetry* (JTAC) (SCI, IF=2.731). (01/2009–12/2010; 01/2018–Present)

- **Editorial Board Editor,** (1) *Process Safety Progress* (PSP) (SCI, IF=0.734). (05/2009–Present), (2) *Journal of Loss Prevention in the Process Industries* (JLPPI) (SCI, IF=2.795). (12/2013–Present), and (3) *Journal of Safety Research* (JSR) (SSCI, IF=2.861). (10/2009–Present)

- **Associate Editor-in-Chief**, *Journal of Occupational Safety and Health*, Council of Labor Affairs, Executive Yuan, Taipei, Taiwan, ROC. (01/2011–04/2014)

Awards and Honors

- **Outstanding Research Award,** Ministry of Science and Technology (MOST), Taiwan. (2018)
- **Fellow,** Royal Society of Chemistry (FRSC), UK. (2018)
- **Fellow,** Institution of Engineering and Technology (IET), UK. (2018)
- **Mettler-Toledo Award,** North American Thermal Analysis Society (NATAS), USA. (2017)
- **Fellow,** American Institute of Chemical Engineers (AIChE) (The 1st recipient from Taiwan in AIChE fellow history), UK. (2016)
- **Best Student Paper Award,** The 6th World Conference on Safety of Oil and Gas Industry, Beijing, P. R. China. (2016)
- **Academic Contribution Award,** Disaster Management Society of Taiwan, Taiwan, ROC. (2016)
- **Honorary Member,** The Phi Tau Phi Scholastic Honor Society of the Republic of China. (2014)
- **International Collaboration Award,** The 5th Sayling Wen Service Science Society of Taiwan. (2014)
- **Outstanding Engineering Professor Award,** Chinese Institute of Engineers, Taichung Branch, Taiwan, ROC. (2014)
- **Chair Professor of Distinguished Alumni,** Tunghai University, Taichung, Taiwan, ROC. (2012)
- **National Distinguished Academician,** Ministry of Education, Executive Yuan,

Taiwan, ROC. (2011)

- **Chemical Engineering Technology Award,** Taiwan Institute of Chemical Engineers, Taiwan, ROC. (2011)
- **Outstanding Academic Research Award,** YunTech. (2007, 2010, 2017)
- **Exceptional Academia-Industry Cooperation Award,** YunTech. (11/2014)
- **Most Cited Author 2006–2009,** The Institution of Chemical Engineers (IChemE), **UK**.
- **Best Paper Awards,** 2009–2012, Annual Conference of the Chinese Institute of Environmental Engineering. (11/06/2009, 11/12/2010, 11/04/2011, 11/16/2012, 11/08/2013, 11/17/2014, 11/14/2015, 11/18/2016, 11/10/2017, 10/19/2018)

Activities in Academic Societies

2019

1. **Chi-Min Shu**, **Conference Chair and Plenary Speaker**, "1st International Conference on Loss Prevention, Process Safety, and Thermal Analysis in Chemical and Coal industries (LPPSTA 2019)", Douliou City, Yunlin, Taiwan, ROC, November 24–27, 2019.
2. **Chi-Min Shu**, **Plenary Speaker**, "The 3rd International Symposium on Urban and Industrial Safety" Jiangsu, Nanjing, China, November 15–17, 2019.
3. **Chi-Min Shu**, **Plenary Speaker**, "18th Symposium on Analytical and Applied Pyrolysis of China (PYRO 2019)", Zhengzhou, China, August 14–18, 2019.
4. **Chi-Min Shu**, **Session Chair**, "The 46th North American Thermal Analysis Society (NATAS)", Newport, Rhode Island, USA, August 5–9, 2019.
5. **Chi-Min Shu**, **Invited Speaker/Session Chair**, "The 2nd Journal of Thermal Analysis and Calorimetry Conference and 7th V4 (Joint Czech-Hungarian-Polish-Slovakian) Thermoanalytical Conference (JTACC+V4)", Budapest, Hungary, June 18–21, 2019.
6. **Chi-Min Shu**, **Vice Chairman**, "2019 International Conference on Urban Public Safety and Emergency Rescue", Changzhou, Jiangsu, China, May 25–26, 2019.

2018

7. **Chi-Min Shu**, **Keynote Speaker**, "The 10th International Workshop on Safety Technology for Pharmaceutical and Chemical Processes", Suzhou, Jiangsu, China, November 8–9, 2018.
8. **Chi-Min Shu**, **Keynote Speaker**, "35th Annual International Pittsburgh Coal Conference", Xuzhou, China, October 15–18, 2018.
9. **Chi-Min Shu**, **Keynote Speaker**, "11th International Mine Ventilation Congress", Xi'an, Shaanxi, China, September 16–18, 2018.
10. **Chi-Min Shu**, **Plenary Speaker/Chair**, "The 45th North American Thermal Analysis Society

(NATAS)", Philadelphia, Pennsylvania, USA, August 6–10, 2018.

2017

1. **Chi-Min Shu**, **Keynote Speaker/Chair**, "The 9th International Workshop on Safety Technology for Pharmaceutical and Chemical Processes", Hangzhou, Zhejiang, China, November 8–10, 2017.
2. **Chi-Min Shu**, **Keynote Speaker/Session Chair**, "The 8th International and 10th Japan-China Joint Symposium on Calorimetry & Thermal Analysis (CATS)", Fukuoka, Japan, November 2–4, 2017.
3. **Chi-Min Shu**, **Keynote Speaker**, "The 8th International Conference on Fire Science and Fire Protection Engineering on the Development of Performance-based Fire Code", Nanjing, Jiangsu, China, October 27–29, 2017.
4. **Chi-Min Shu, Plenary Speaker**, "The 44th North American Thermal Analysis Society (NATAS)", Newark, Delaware, August 7–10, 2017.
5. **Chi-Min Shu**, **Session Chair**, "Journal of Thermal Analysis and Calorimetry Conference (JTACC)", Budapest, Hungary, June 4–9, 2017.

2016

1. **Chi-Min Shu**, **Co-Chair**, "2016 International Confederation for thermal analysis and calorimetry (ICTAC)", Orlando, Florida, USA, August 14–19, 2016.
2. **Chi-Min Shu**, **Program Organizer/Plenary Speaker**, "The 3rd Academic Forum on Cross-Strait of Industrial Safety", Yunlin, Taiwan, ROC, June 16–17, 2016.

2015

1. **Chi-Min Shu**, **Co-Chair**, "The 43th North American Thermal Analysis Society (NATAS)", Ottawa, Ontario, Canada, August 10–13, 2015.
2. **Chi-Min Shu**, **Plenary Speaker**, "The 2nd Academic Forum on Cross-Strait of Industrial Safety", Xi'an, Shaanxi, China, April 10–17, 2015.
3. **Chi-Min Shu**, **Program Organizer/Plenary Speaker**, "The 1st Forum on Cross-strait of

Industrial Security", Yunlin, Taiwan, ROC, January 21–22, 2015.

2014

1. **Chi-Min Shu**, **Chair/Plenary Speaker**, "2014 International Symposium on Safety Science and Technology (ISSST)", Beijing, China, November 4–5, 2014.
2. **Chi-Min Shu**, **Co-Organizer/Keynote Speaker**, "15th International Conference of the Union of Materials Research Societies in Asia (IUMRS-ICA)", Fukuoka, Japan, August 24–30, 2014.

2013

1. **Chi-Min Shu**, **Poster Session Chair/Technical Program Co-Chair/Keynote Speaker**, "The 41th North American Thermal Analysis Society (NATAS)", Bowling Green, Kentucky, USA, August 4–7, 2013.

2012

1. **Chi-Min Shu**, **Keynote Speaker/Referee/Chair**, "2012 International Congress on Thermal Analysis and Calorimetry (ICTAC)", Kinki University, Osaka, Japan, August 21–24, 2012.

2011

1. **Chi-Min Shu**, **Plenary Speaker/Keynote Speaker**, "2011 Annual Conference & International Workshop on Intensive Loading and Its Effects –Evaluations on thermal runaway characteristics for three liquid organic peroxides", Beijing, China, December 13–14, 2011.
2. **Chi-Min Shu**, **Keynote Speaker**, "The 39th North American Thermal Analysis Society (NATAS)", Des Moines, Iowa, USA, August 7–10, 2011.

2010

1. **Chi-Min Shu**, **Keynote Speaker**, "2010 International Security Technology & Management Conference (ISTAM)", Taipei, Taiwan, ROC, September 8–10, 2010.

2009

1. **Chi-Min Shu**, **Keynote Speaker**, "The 37th North American Thermal Analysis Society

(NATAS)", Lubbock, Texas, USA, September, 20–23, 2009.

2008

1. **Chi-Min Shu**, **Keynote Speaker**, "2008 Taiwan/Korea/Japan Chemical Engineering Conference and 55th Taiwan Institute of Chemical Engineers Annual Conference", Taipei, Taiwan, ROC, November 21, 2008.
2. **Chi-Min Shu**, **Co-chair**, "International Occupational Hygiene Association 7th International Scientific Conference (IOHA 2008)", Taipei, Taiwan, ROC, February 18–22, 2008.

List of publications since 2021–

- **2021**

1. Yi-Ming Chang, Chi-Min Shu, Mei-Li You, 2021. Explosion prevention and weighting analysis on the inerting effect of methane via grey entropy model, Journal of Loss Prevention in the Process Industries. 104385 (SCI). Available online IF: 2.795, Journal ranking: 57/143, Q2. (https://doi.org/10.1016/j.jlp.2020.104385)
2. Weiguo Cao, Wenjuan Li, Shuo Yu, Yun Zhang, Chi-Min Shu, Yifei Liu, Jingwen Luo, Lingtao Bu, Yingxin Tan, 2020. Explosion venting hazards of temperature effects and pressure characteristics for premixed hydrogen-air mixtures in a spherical container, Fuel. Volume 290, 120034 (SCI). (Corresponding Author) IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2020.120034)
3. Yet-Pole I, Application of CFD modeling and 3D QRA technique in analysis of an LPG tank explosion accident, Journal of Loss Prevention in the Process Industries Accepted
4. Effect of oxygen concentration on combustion residues of polymerised styrene-butadiene rubber 1502, 2020. Journal of Thermal Analysis and Calorimetry Accepted
5. Effects of moisture content on explosion characteristics of incense dust in incense factory, Journal of Thermal Analysis and Calorimetry Accepted
6. Evaluation of the dust potential hazard of thermal power plants through coal dust combustion and explosion characteristics, Journal of Thermal Analysis and Calorimetry Accepted
7. Autocatalytic decomposition properties and thermal decomposition of benzoyl peroxide Accepted
8. Modeling thermal analysis for predicting thermal hazards relevant to transportation safety and runaway reaction for 2,2'-azobis(isobutyronitrile) Accepted

- **2020**

9. Bei Li, Mengjia Li, Wei Gao, Mingshu Bi, Li Ma, Qihua Qin, and **Chi-Min Shu**. 2020, "Effects of particle size on the self-ignition behaviour of a coal dust layer on a hot plate", *Fuel*. Volume 260, 116269 (SCI). **(Corresponding Author)** IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2019.116269)
10. Pengxiang Zhao, Risheng Zhuo, Shugang Li, **Chi-Min Shu**, Bin Laiwang, Yongyong Jia, Yu Shi, and Liang Suo. 2020, "Analysis of advancing speed effect in gas safety extraction channels and pressure-relief gas extraction", *Fuel*. Volume 265, 116828 (SCI). **(Corresponding Author)** IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2019.116825)
11. Bin Zhang, Shang-Hao Liu, Jie Liu, Zhi-He Zhang, Bin Laiwang, and **Chi-Min Shu**. 2020, "Thermal stability and flammability assessment of 1-ethyl-2, 3-dimethylimidazolium nitrate", *Process Safety and Environmental Protection*. Volume 135, pp. 219–227 (SCI). **(Corresponding Author)** IF: 4.966, Journal ranking: 23/143, Q1. (https://doi.org/10.1016/j.psep.2020.01.001)
12. Pei-Hsuan Tung, Bin Laiwang, **Chi-Min Shu**, and Kuang-Hua Hsueh. 2020, "Thermogravimetric evaluation of the effect of $LiBF_4$ on the thermal stability of three engine lubricants", *Journal of Molecular Liquids.* Volume 297, 111842 (SCI). **(Corresponding Author)** IF: 5.065, Journal ranking: 4/37, Q1. (https://doi.org/10.1016/j.molliq.2019.111842)
13. Yun Zhang, Weiguo Cao, **Chi-Min Shu**, Mengke Zhao, Cunjuan Yu, Zhaobian Xie, Jinhu Liang, Zhiqiang Song, and Xiong Cao. 2020, "Dynamic hazard evaluation of explosion severity for premixed hydrogen-air mixtures in a spherical pressure vessel", *Fuel*. Volume 261, 116433 (SCI). **(Corresponding Author)** IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2019.116433)
14. Xinmiao Liang, Yu-Chi Cheng, Wei-Cheng Lin, Pei-Hsuan Tung, Hao-Qun Huang, Xuhai Pan, **Chi-Min Shu**, and Juncheng Jiang. 2020, "Analysis and characterisation of 1-butyl-3-methylimidazolium hexafluorophosphate as a humectant of nitrocellulose", *Journal of Molecular Liquids.* Volume 303, 112617 (SCI). **(Corresponding Author)** IF: 5.065, Journal ranking: 4/37, Q1. (https://doi.org/10.1016/j.molliq.2020.112617)
15. Juncheng Jiang, Weijia Duan, Qian Wei, Xinyue Zhao, Lei Ni, Yong Pan, and **Chi-Min Shu**. 2020, "Development of quantitative structure-property relationship (QSPR) models for predicting the thermal hazard of ionic liquids: A review of methods and models", *Journal of Molecular Liquids.* Volume 301, 112471 (SCI). **(Corresponding Author)** IF: 5.065, Journal ranking: 4/37, Q1. (https://doi.org/10.1016/j.molliq.2020.112471)
16. Qian Yu, Shang-Hao Liu, Zi-Ru Guo, Chen-Rui Cao, Lai-Wang Bin, and **Chi-MinShu**. 2020, "Thermal decomposition characteristics of diethyl azodicarboxylate dissolved in three ionic liquids as solvents", *Journal of Molecular Liquids.* Volume 302, 112564 (SCI). **(Corresponding Author)** IF: 5.065, Journal ranking: 4/37, Q1. (https://doi.org/10.1016/j.molliq.2020.112564)
17. Qiuhong Wang, Xiang Fang, **Chi-Min Shu**, Qingfeng Wang, Youjie Sheng, Juncheng Jiang, Yilin Sun, and Zhongyi Sheng. 2020, "Minimum ignition temperatures and explosion characteristics of micron-sized aluminium powder", *Journal of Loss Prevention in the Process Industries*. Volume 64, 104076 (SCI). IF: 2.795, Journal ranking: 57/143, Q2. (https://doi.org/10.1016/j.jlp.2020.104076)
18. Miao Liang, Ke Zhang, Ping Lei, Bing Wang, **Chi-Min Shu**, and Bin Li. 2020, "Fuel properties and combustion kinetics of hydrochar derived from co-hydrothermal carbonization of tobacco

residues and graphene oxide", *Biomass Conversion and Biorefinery*. Volume 10(1), pp. 189–201 (SCI). IF: 2.602, Journal ranking: 65/143, Q2. (https://doi.org/10.1007/s13399-019-00408-2)

19. Li Bei, Liu Gang, Gao Wei, Cong Hai-Yong, Bi Min-Shu, Ma Li, Deng Jun, and **Chi-Min Shu**. 2020, "Study of combustion behaviour and kinetics modelling of Chinese Gongwusu coal gangue: Model-fitting and model-free approaches", *Fuel*. Volume 268, 117284 (SCI). **(Corresponding Author)** IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2020.117284)
20. Yun Zhang, Renkang Chen, Mengke Zhao, Jingwen Luo, Weisen Feng, Wenqi Fan, Yingxin Tan, Weiguo Cao, **Chi-Min Shu**, and Cunjuan Yu. 2020, "Hazard evaluation of explosion venting behaviours for premixed hydrogen-air fuels with different bursting pressures", *Fuel*. Volume 268, 117313 (SCI). **(Corresponding Author)** IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2020.117284)
21. Anjani R. K. Gollakota, Sneha Gautam, and **Chi-Min Shu**. 2020, "Inconsistencies of E-Waste Management in Developing Nations-Facts and plausible solutions", *Journal of Environmental Management*. Volume 261, 110234 (SCI). **(Corresponding Author)** IF: 5.647, Journal ranking: 33/265, Q1. (https://doi.org/10.1016/j.jenvman.2020.110234)
22. Haitao Li, Jun Deng, Xiaokun Chen, **Chi-Min Shu**, Chia-Ho Kuo, Xiaowei Zhai, Qiuhong Wang, and Xiangyu Hua. 2020, "Transient temperature evolution of pulverized coal cloud deflagration in a methane-oxygen atmosphere", *Powder Technology*. Volume 366, pp. 294–304 (SCI). IF: 4.142, Journal ranking: 31/143, Q1. (https://doi.org/10.1016/j.powtec.2020.02.042)
23. Shang-Hao Liu, Chen-Rui Cao, and **Chi-Min Shu**. 2020, "Using thermal analysis with kinetic calculation method to assess the thermal stability of 2-cyanopropan-2-yliminourea", *Journal of Loss Prevention in the Process Industries*. Volume 64, 104084 (SCI). **(Corresponding Author)** IF: 2.795, Journal ranking: 57/143, Q2. (https://doi.org/10.1016/j.jlp.2020.104084)
24. Qiuhong Wang, Yilin Sun, Juncheng Jiang, Jun Deng, **Chi-Min Shu**, Zhenmin Luo, and Qingfeng Wang. 2020, "Inhibiting effects of gas–particle mixtures containing CO_2, $Mg(OH)_2$ particles, and $NH_4H_2PO_4$ particles on methane explosion in a 20-L closed vessel", *Journal of Loss Prevention in the Process Industries*. Volume 64, 104082 (SCI). **(Corresponding Author)** IF: 2.795, Journal ranking: 57/143, Q2. (https://doi.org/10.1016/j.jlp.2020.104082)
25. Yang-Fan Cheng, Hong-Bo Wu, Rong Liu, Yu-Le Yao, Jian Su, Wen-Tao Wang, and **Chi-Min Shu**. 2020, "Combustion behaviors and explosibility of suspended metal hydride TiH_2 dust", *International Journal of Hydrogen Energy*. Volume 45, Issue 21, pp. 12216–12224 (SCI). **(Corresponding Author)** IF: 4.939, Journal ranking: 48/159, Q2. (https://doi.org/10.1016/j.ijhydene.2020.02.137)
26. Pengxiang Zhao, Risheng Zhuo, Shugang Li, Haifei Lin, **Chi-Min Shu**, Bin Laiwang, Yongyong Jia, and Liang Suo. 2020, "Fractal characteristics of gas migration channels at different mining heights", *Fuel*. Volume 271, 117479 (SCI). **(Corresponding Author)** IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2020.117479)
27. Zeyang Song, Maorui Li, Yong Pan, and **Chi-Min Shu**. 2020, "A generalized differential method to calculate lumped kinetic triplet of the nth order model for the global one-step heterogeneous reaction using TG data", *Journal of Loss Prevention in the Process Industries*. Volume 64, 104094 (SCI) IF: 2.795, Journal ranking: 57/143, Q2. (https://doi.org/10.1016/j.jlp.2020.104094)
28. Da-Jiang Li, Yang Xiao, Hui-Fei Lü, Fan Xu, Kun-Hua Liu, and **Chi-Min Shu**. 2020, "Effects of 1-butyl-3-methylimidazolium tetrafluoroborate on the exothermic and heat transfer

characteristics of coal during low-temperature oxidation", *Fuel*. Volume 273, 117589 (SCI). **(Corresponding Author)** IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2020.117589)

29. Haitao Li, Jun Deng, Xiaokun Chen, **Chi-Min Shu**, Chia-Ho Kuo, and Xiangyu Hu. 2020, "Influence of ignition delay on explosion severities of the methane-coal particle hybrid mixture at elevated injection pressures", *Powder Technology*. Volume 367, pp. 860–876 (SCI). **(Corresponding Author)** IF: 4.142, Journal ranking: 31/143, Q1. (https://doi.org/10.1016/j.powtec.2020.04.034)
30. Hao Ji, Wei Zhang, Xu-Hai Pan, Min Hua. Yi-Hong Chung, **Chi-Min Shu**, and Li-Jing Zhang. 2020, "State of health prediction model based on internal resistance", *International Journal of Energy Research*. Volume 44, Issue 8 (SCI) **(Corresponding Author)** IF: 4.939, Journal ranking: 48/195, Q2. (https://doi.org/10.1002/er.5383)
31. Shu-Yao Tsai, Yu-Ching Hsu, **Chi-Min Shu**, Kuei-Hua Lin, and Chun-Ping Lin. 2020, "Synchronization of isothermal calorimetry and liquid cultivation identifying the beneficial conditions for producing ethanol by yeast Saccharomyces cerevisiae fermentation", *Journal of Thermal Analysis and Calorimetry*. Volume 142, pp. 829–840 (SCI) IF: 2.731, Journal ranking: 18/61, Q2. (https://doi.org/10.1007/s10973-020-09629-4)
32. Qing-Wei Li, Yang Xiao, Kai-Qi Zhong, **Chi-Min Shu**, Hui-Fei Lü, Jun Deng, and Shiliang Wu. 2020, "Overview of commonly used materials for coal spontaneous combustion prevention", *Fuel*. Volume 275, 117981 (SCI). IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2020.117981)
33. Haitao Li, Jun Deng, **Chi-Min Shu**, Chia-Ho Kuo, Yong-chuan Yu, and Xiangyu Hu. 2020, "Flame behaviours and deflagration severities of aluminium powder-air mixture in a 20-L sphere: Computational fluid dynamics modelling and experimental validation", *Fuel*. Volume 276, 118028 (SCI) IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2020.118028)
34. Chen-Rui Cao, Wei-Chun Chen, and **Chi-Min Shu**. 2020, "Prediction and assessment of fly-up type of fireworks by thermokinetics model", *Journal of Thermal Analysis and Calorimetry*. Volume 142, pp. 927–936 (SCI). **(Corresponding Author)** IF: 2.731, Journal ranking: 18/61, Q2. (https://doi.org/10.1007/s10973-020-09840-3)
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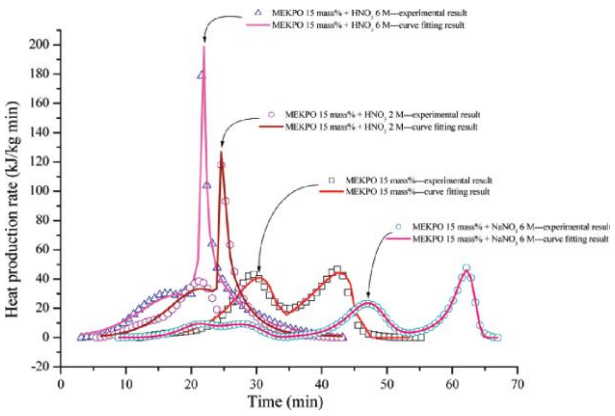
Fundamental research

Research topic A:

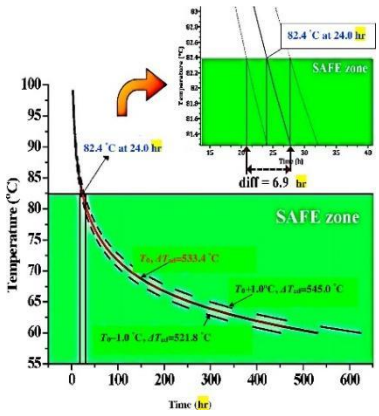
Adoption of chemical reaction model on organic peroxides by calorimetry and differential isoconversional kinetic analysis.

Descriptions of the academic contributions

The peroxyl group is exceptionally active and unstable, while the remainder of the molecule is inert. There are numerous organic peroxides, such as cumene hydroperoxide (CHP), 2,5-dimethyl-2,5-di-(tert-butylperoxy) hexane (DBPH), methyl ethyl ketone peroxide (MEKPO). CHP reacts with various concentrations of dilute sodium hydroxide as a catalyst to cleave at ambient and decomposition temperature. MEKPO combined with HNO_3 has three exothermic peaks, and forms an extraordinarily hazardous mixture. It has also established an efficient benchmark for a thermal hazard assessment of CHP, DBPH, and MEKPO that can be applied to assure safer storage.



Fitting of experimental data sets on heat production rate for MP4, MN2, MN6, and MNA by the kinetic functions.



Thermal safety diagram for DBPH under fully adiabatic conditions with Ø = 1.0.

Related publications

- Mitali Das and **Chi-Min Shu**. 2016, "A green approach towards adoption of chemical reaction model on 2, 5-Dimethyl-2, 5-di-(tert-butylperoxy) hexane decomposition by differential isoconversional kinetic analysis", *Journal of Hazardous Materials*. Volume 301, pp. 222–232 (SCI). IF: 9.038, Journal ranking: 8/265, Q1 **(Corresponding Author)** (https://doi.org/10.1016/j.jhazmat.2015.09.005)
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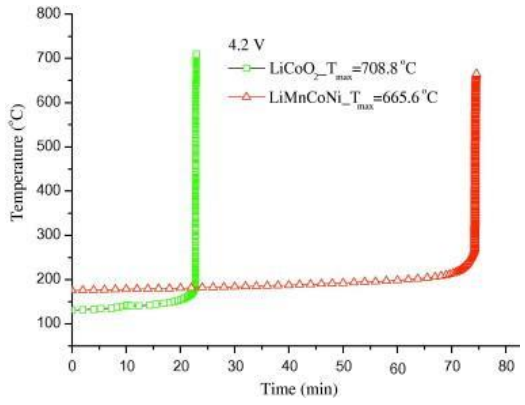
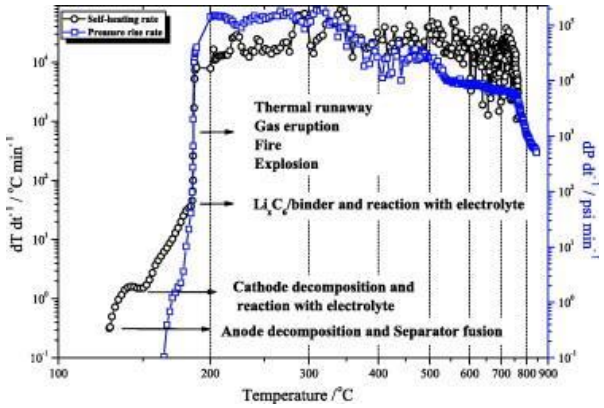
- Houng-Yi Hou, Tung-Lin Tsai, and **Chi-Min Shu**. 2008, "Reactions of cumene hydroperoxide mixed with sodium hydroxide", *Journal of Hazardous Materials*. Volume 152, pp. 1214–1219 (SCI). IF: 9.038, Journal ranking: 8/265, Q1. **(Corresponding Author)** (https://doi.org/10.1016/j.jhazmat.2007.07.118)

Research topic B:
Mechanisms of lithium ion battery thermal runaway and thermal explosion.

Descriptions of the academic contributions
Numerous accidents have been reported due to thermal runaway phenomena in lithium-ion batteries (LIBs); this is a key scientific problem in battery safety research. Thermal runaway is a complex chain chemical reaction that affects various components of a battery. Thus, an inherently safer LIB design is a paramount concern that is crucial for a futuristic outlook. Hence, a detailed analysis of the characterization of these active materials is highly desired to obtain a closer insight on their physicochemical properties, reaction kinetics, electrochemical, or chemical reactions, and thermal stability. In lieu of this, the Process Safety & Disaster Prevention Laboratory (PS&DPL) research team focused mainly on thermal analytical techniques (adiabatic calorimetry) of LIBs (18650), such as an exothermic screening test that evaluated the exothermic activity, enthalpy, temperature, and pressure trajectories, to analyze the thermal runaway behavior of LIBs.



Temperature–time profiles of 4.2 V Li-ion batteries ($LiCoO_2$ and LiMnCoNi) by VSP2 adiabatic tests.



Self-heating rate and pressure rise rate of the charged 18650 Sony Li-ion battery by a VSP2 adiabatic test is outlining four stages of thermal runaway.

Related publications
- Wei-Chun Chen, Yih-Wen Wang, and **Chi-Min Shu**. 2016, "Adiabatic calorimetry test of the reaction kinetics and self–heating model for 18650 Li-ion cells in various states of charge", *Journal of power sources*. Volume 318, pp. 200–209 (SCI). IF: 8.247, Journal ranking: 34/285, Q1. (https://doi.org/10.1016/j.jpowsour.2016.04.001)
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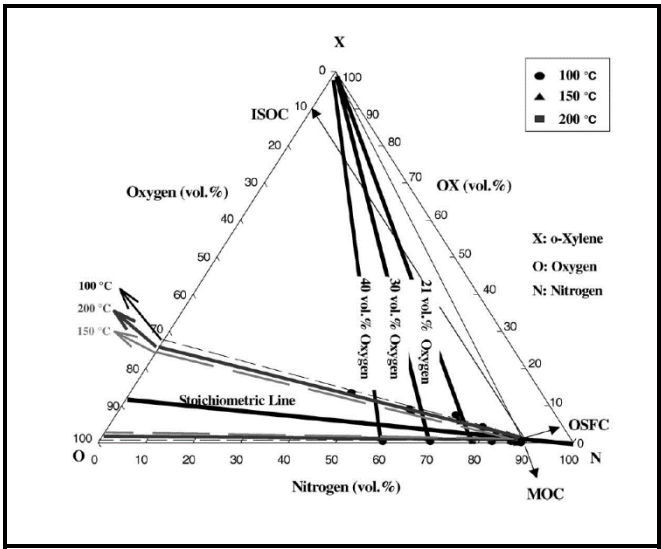
Research topic C:

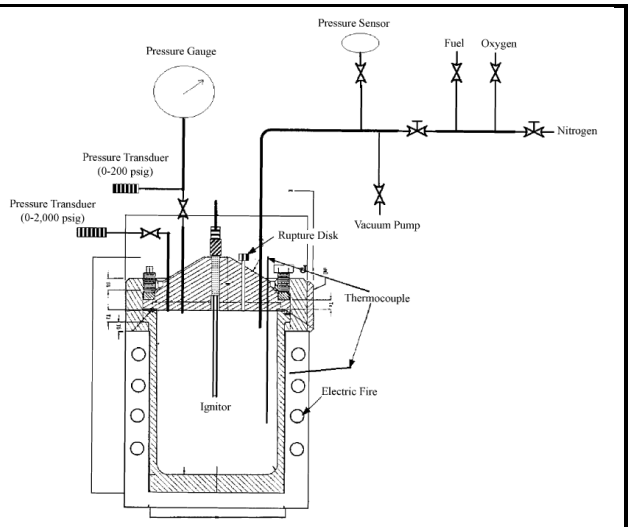
Derived detonation mechanism of *o*-xylene (OX) and installed the system disaster prevention mechanism and countermeasures.

Descriptions of the academic contributions

Taiwan was once the second largest producer of phthalic anhydride (PA) in the world after the United States. With the time and space background at the time, no numerical model could accurately predict the flammability limit of o-xylene in the flammable raw material in the actual phthalic anhydride chemical process. Through the systematic use of combustion theory, chemistry and numerous experimental pieces of evidence, the empirical equations of the gas phase, and liquid/gas two-phase were successfully established for the first time. It also provides a reference for industry and related research fields.



Overall triangular flammability diagram contrasting the change in flammability zone with OX at 760 mmHg and three different initial temperature.



A schematic diagram of 1-L-Apparatus for the determination of explosion characteristics of OX.

Related publications

- Po-Jiun Wen and Ron-Hsin Chang, and **Chi-Min Shu**. 2002, "Investigations on flammability models and zones for o-Xylene under various initial pressures, temperatures and oxygen concentrations", *Thermochimica Acta*. Volume392, pp. 271–287. (SCI). IF: 2.762, Journal ranking: 17/61, Q2. (**Corresponding Author**) (https://doi.org/10.1016/S0040-6031(02)00110-7)
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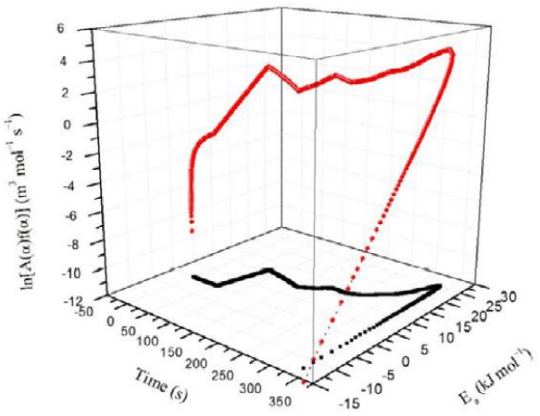
Research topic D:

Evaluation of thermal stability of cosmeceuticals using calorimetric technology and establishment of thermodynamic models.

Descriptions of the academic contributions

In cosmeceuticals studies, benzoyl peroxide, malic acid, salicylic acid, and essential oil were evaluated via various calorimeters and analytical approaches to establishing a reasonable and safer design for industrial operation. The thermokinetic models of different acne treatments and aromatherapy cosmeceuticals were established. Moreover, simulations of various cosmeceuticals adding trace metal, acid, or alkali elements were achieved. The findings for thermokinetic parameters can be provided to relevant research areas and industrial process safety as well as quality enhancement design.



Tea tree essential oil DSC isothermal experiments on 3D scatter graph on time, E_a, and ln[A(α)f(α)].

Related publications

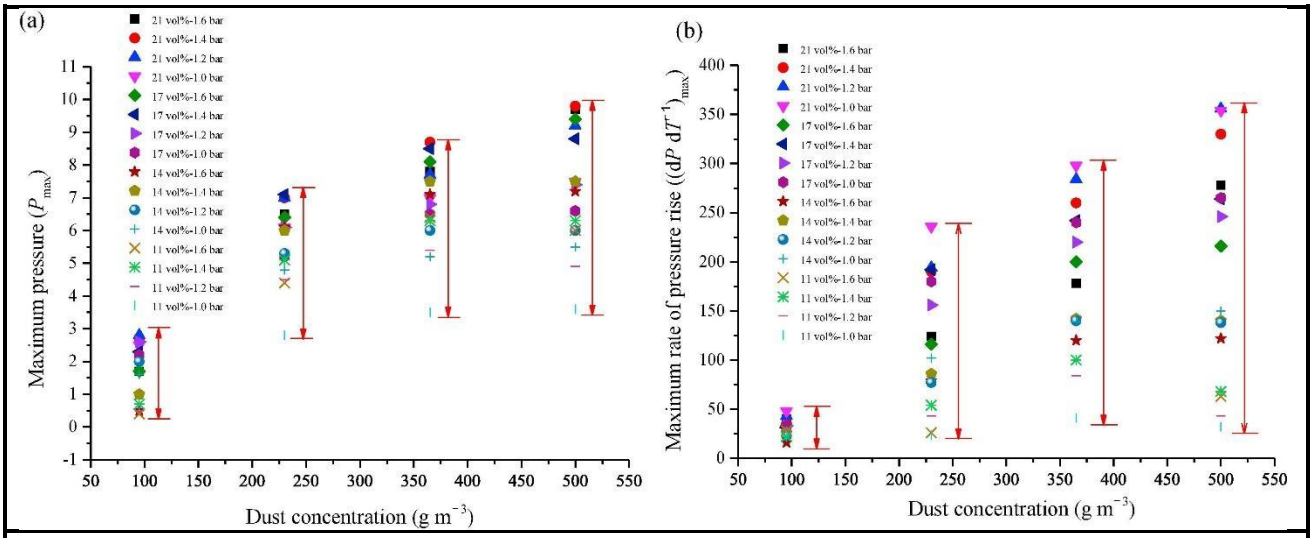
- Wei-Ting Chen, Wei-Chun Chen, Chih-Ming Ma, Bin Laiwang, Sun-Ju Shen, Mei-Li You, and **Chi-Min Shu**. 02/2018, "Structural characteristics and decomposition analyses of four commercial essential oils by thermal approaches and GC/MS", *Journal of Thermal Analysis and Calorimetry*. Volume 131, pp. 1709–1719 (SCI). IF: 2.731, Journal ranking: 18/61, Q2.
- An-Chi Huang, Yu-Kai Chuang, Chung-Fu Huang, and **Chi-Min Shu**. 04/2018, "Thermokinetic analysis of the stability of malic and salicylic acids in cosmeceutical formulations containing metal oxides", *Journal of Thermal Analysis and Calorimetry*. Volume 132, pp. 165–172 (SCI). IF: 2.731, Journal ranking: 18/61, Q2.
- Quan Wang, Shang-Hao Liu, An-Chi Huang, Chung-Fu Huang, Yu-Kai Chuang, and **Chi-Min Shu**. 01/2018, "Effects of mixing malic acid and salicylic acid with metal oxides in medium- to low-temperature isothermal conditions, as determined using the thermal activity monitor IV", *Journal of Thermal Analysis and Calorimetry*. Volume 133, pp. 779–784 (SCI). IF: 2.731, Journal ranking: 18/61, Q2.

Research topic E:

Study on process dust explosion parameters for inherently safer design.

Descriptions of the academic contributions

The recent years have witnessed the vigorous development of digital products and the continuous improvement of traditional daily necessities. Powdery substances are produced and used in large quantities in the process and caused frequent accidents of dust explosions. To prevent businesses and workers from being exposed to high-risk dust explosions, we focused on dust explosions in recent years. Dust explosion assessment for powder polyester resin process covered its raw materials, products, and process parameters. International standards have been applied to establish the explosion parameters suitable for the current state of the process. The results could provide scientific data to enable companies to make appropriate fire and explosion protection designs and quantify risks, as well as mitigate reduce and prevent the occurrence of dust explosions in an efficient and economical manner.



Maximum pressure and maximum pressure rise rate versus dust concentration for polyester resin.

Related publications

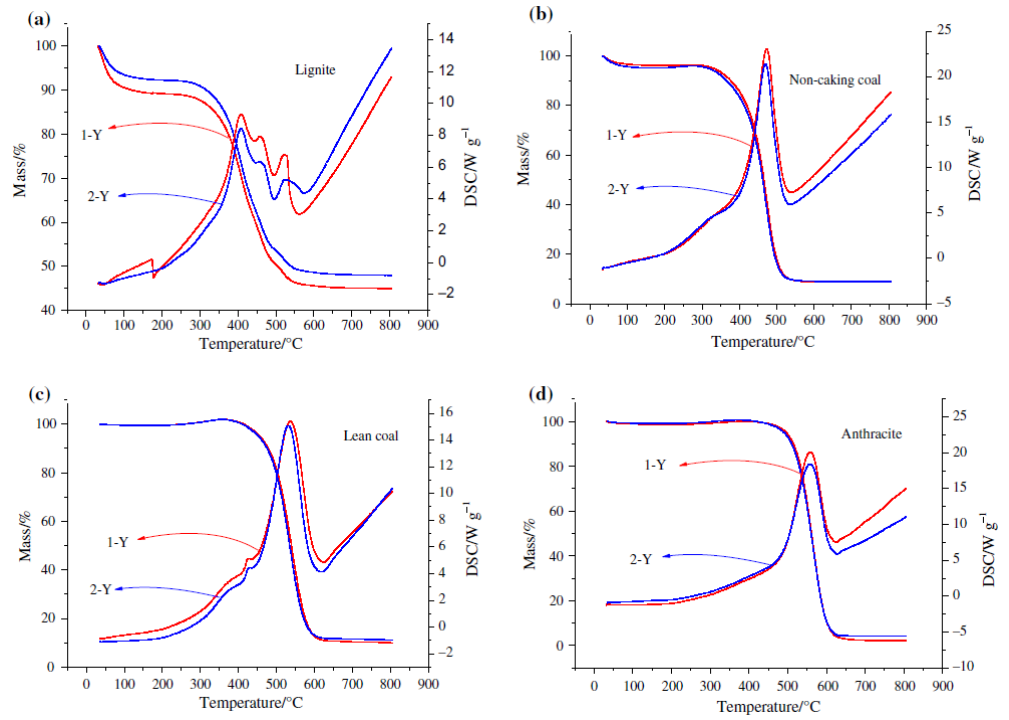
- Yun-Ting Tsai, Sing-Cheng Ho, An-Chi Huang, and **Chi-Min Shu**. 2018, "Potential explosion hazard of polyester resin dust formed from a granulation process: limiting oxygen concentration with different pressures", *Applied Thermal Engineering*. Volume 135, pp. 74–82 (SCI). IF: 4.725, Journal ranking: 13/136, Q1. (https://doi.org/10.1016/j.applthermaleng.2018.02.047)
- Sheng-Yi Lin, Tzu-Hao Lin, Yen-Chun Cheng, Kuang-Hua Hsueh, and **Chi-Min Shu**. 2016, "Assessment of dust explosion with adipic acid and p–terephthalic acid in powder resin process", *Journal of Loss Prevention in the Process Industries.* Volume 43, pp. 92–97 (SCI). IF: 2.795, Journal ranking: 57/143, Q2. (**Corresponding Author**) (https://doi.org/10.1016/j.jlp.2016.05.003)
- Tzu-Hao Lin, Sheng-Yi Lin, Kuang-Hua Hsueh, Mei-Li You, and **Chi-Min Shu**. 2017, "Dust explosion parameters of polyester resin", *Journal of Thermal Analysis and Calorimetry.* Volume 127, pp. 1037–1045 (SCI). IF: 2.731, Journal ranking: 18/61, Q2. (**Corresponding Author**)

Research topic F:

Research on the thermodynamic reaction mechanism of coal.

Descriptions of the academic contributions

Coal spontaneous combustion and its persistence have been one of the major features, and the mechanism of spontaneous combustion of coal is not yet fully understood. Coal spontaneous combustion belongs to the composite reaction of coal and oxygen, and its spontaneous combustion process has typical thermodynamic characteristics. Therefore, based on the thermodynamic characteristics of spontaneous coal combustion, the characteristics of coal spontaneous combustion (thermal diffusivity, specific heat capacity, and thermal conductivity) and the reaction kinetic reaction mechanism (key functional groups participating in the order of importance of reaction) were established. Furthermore, the thermodynamic reaction mechanism of spontaneous coal combustion was further enriched.



Heat release of TG–DSC curves with temperature change. (a) ® = 5.0 C min^{-1}; lignite, (b) ® = 5.0 ^{o}C min^{-1}; non-caking coal, (c) ® = 5.0 ^{o}C min^{-1}; lean coal, (d) ® = 5.0 ^{o}C min^{-1}; anthracite.

Related publications

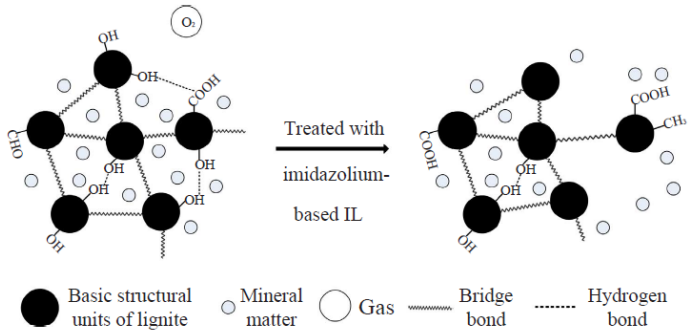
- Changkui Lei, Jun Deng, Kai Cao, Yang Xiao, Li Ma, Weifeng Wang, Teng Ma, and **Chi-Min Shu**. 03/2019, "A comparison of random forest and support vector machine approaches to predict coal spontaneous combustion in gob", *Fuel*. Volume 239, pp. 297–311 (SCI). IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2018.11.006)
- An-Chi Huang, Chung-Fu Huang, Jing-Yu Zhao, Jun Deng, Terng-Jou Wan, and **Chi-Min Shu**. 01/2018, "Microcosmic thermal analysis of coal mixed with oxides at different temperatures", *International Journal of Oil Gas and Coal Technology*. Volume 18, pp. 239–254 (SCI). IF: 0.752, Journal ranking: 14/19, Q3. (DOI: 10.1504/IJOGCT.2018.091515)
- Jun Deng, Qing-Wei Li, Yang Xiao, Cai-Ping Wang, and **Chi-Min Shu**. 01/2018, "Thermal diffusivity of coal and its predictive model in nitrogen and air atmospheres", *Applied Thermal*

Engineering. Volume 130, pp. 1233–1245 (SCI). IF: 4.725, Journal ranking: 13/136, Q1. (https://doi.org/10.1016/j.applthermaleng.2017.11.102)

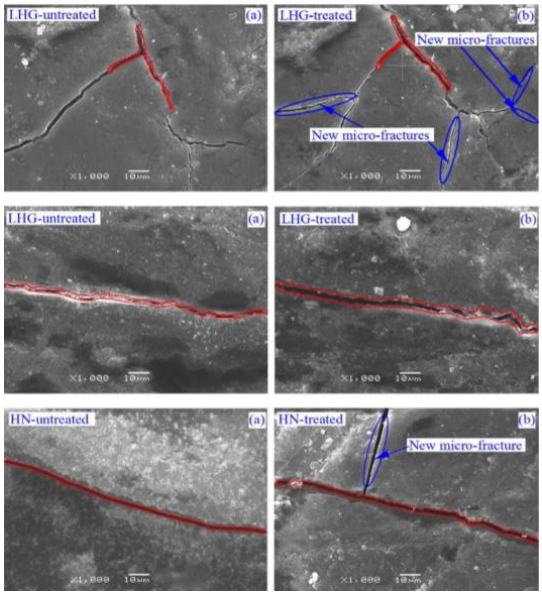
- Yang Xiao, Hui-Fei, Lü, An-Chi Huang, Jun Deng, and **Chi-Min Shu**. 02/2018, "A new numerical method to predict the growth temperature of spontaneous combustion of 1/3 coking coal", *Applied Thermal Engineering*. Volume 131, pp. 221–229 (SCI). IF: 4.725, Journal ranking: 13/136, Q1. **(Corresponding Author)** (https://doi.org/10.1016/j.applthermaleng.2017.12.007)
- Haitao Li, Xiaokun Chen, **Chi-Min Shu**, Qiuhong Wang, Teng Ma, and Bin Laiwang. 04/2018, "Effects of oxygen concentration on the macroscopic characteristic indexes of high-temperature oxidation of coal", *Journal of the Energy Institute*. Volume 92, Issue 3, pp. 554–566 (SCI). IF: 4.748, Journal ranking: 33/112, Q2. **(Corresponding Author)** (https://doi.org/10.1016/j.joei.2018.04.003)
- Yang Xiao, Shuai-Jing Ren, Jun Deng, and **Chi-Min Shu**. 09/2018, "Comparative analysis of thermokinetic behavior and gaseous products between first and second coal spontaneous combustion", *Fuel*. Volume 227, pp. 325–333 (SCI). IF: 5.578, Journal ranking: 18/143, Q1. (https://doi.org/10.1016/j.fuel.2018.04.070)
- Jun Deng, Qing-Wei Li, Yang Xiao, and **Chi-Min Shu**. 01/2017, "Experimental study on the thermal properties of coal during pyrolysis, oxidation, and re-oxidation", *Applied Thermal Engineering*. Volume 110, pp. 1137–1152 (SCI). IF: 4.725, Journal ranking: 13/136, Q1. (https://doi.org/10.1016/j.applthermaleng.2016.09.009)
- Jun Deng, Bei Li, Yang Xiao, Li Ma, Cai-Ping Wang, Bin Laiwang, and **Chi-Min Shu**. 04/2017, "Combustion properties of coal gangue using thermogravimetry–fourier transform infrared spectroscopy", *Applied Thermal Engineering*. Volume 116, pp. 244–252 (SCI). IF: 4.725, Journal ranking: 13/136, Q1. (Corresponding Author) (https://doi.org/10.1016/j.applthermaleng.2017.01.083)
- Jun Deng, Jing-Yu Zhao, An-Chi Huang, Yan-Ni Zhang, Cai-Ping Wang, and **Chi-Min Shu**. 01/2016, "Thermal behavior and microcharacterization analysis of second–oxidized coal", *Journal of Thermal Analysis and Calorimetry*. Volume 127, pp. 439–448 (SCI). IF: 2.731, Journal ranking: 18/61, Q2. (https://doi.org/10.1007/s10973-016-5493-8)
- Zhen-Min Luo, Fang-Ming Cheng, Tao Wang, Jun Deng, and **Chi-Min Shu**. 04/2016, "Suppressive effects of silicon dioxide and diatomite powder aerosols on coal mine gas explosions in highlands", *Aerosol and Air Quality Research*. Volume 16, pp. 2119–2128 (SCI). IF: 2.735, Journal ranking: 97/251, Q2. (https://doi.org/10.4209/aaqr.2015.11.0633)
- Yang Xiao, Qing-Wei Li, Jun Deng, **Chi-Min Shu**, and Wei Wang. 08/2016, "Experimental study on the corresponding relationship between the index gases and critical temperature for coal spontaneous combustion", *Journal of Thermal Analysis and Calorimetry*. Volume 127, Issue 1, pp. 1009–1017 (SCI). IF: 2.731, Journal ranking: 18/61, Q2. (https://doi.org/10.1007/s10973-016-5770-6)

Research topic G:
Establishment on technologies to inhibit spontaneous coal combustion.

Descriptions of the academic contributions
The coal fire disaster had a wide range. In the near-surface coal field fires, a large number of coal resources burned out, which also endangered public safety and created air pollution. However, staff had limited knowledge of coal fires. Sometimes they did not use inhibitors but substances that were easily fired, which triggered a larger coal fire. To grasp the way of thermal decomposition and the essential hazard characteristics of coal, it was crucial to establish methods and technologies for suppressing spontaneous combustion of coal.



Mechanism of imidazolium-based IL treatment of lignite.



SEM images of (a) untreated and (b) treated coal samples.

Related publications
- Hu Wen, Zhenbao Li, Jun Deng, **Chi-Min Shu,** Bin Laiwang, Qiuhong Wang, and Li Ma. 10/2017, "Influence on coal pore structure during liquid CO_2-ECBM process for CO_2 utilization", *Journal of CO_2 Utilization*. Volume 21, pp. 543–552 (SCI). IF: 5.993, Journal ranking: 14/143, Q1. **(Corresponding Author)** (https://doi.org/10.1016/j.jcou.2017.09.002)
- Yi Yang, Yun-Ting Tsai, Yanni Zhang, **Chi-Min Shu**, and Jun Deng. 01/2018, "Inhibition of spontaneous combustion for different metamorphic degrees of coal using Zn/Mg/Al–CO_3 layered double hydroxides", *Process Safety and Environmental Protection*. Volume 113, pp. 401–412 (SCI). IF: 4.966, Journal ranking: 23/143, Q1. (https://doi.org/10.1016/j.psep.2017.11.011)
- Fu-Sheng Cui, Bin Laiwang, **Chi-Min Shu**, and Jun-Cheng Jiang. 04/2018, "Inhibiting effect of imidazolium-based ionic liquids on the spontaneous combustion characteristics of lignite", *Fuel*. Volume 217, pp. 508–514 (SCI). IF: 5.578, Journal ranking: 18/143, Q1. **(Corresponding Author)** (https://doi.org/10.1016/j.fuel.2017.12.092)
- Jun Deng, Zu-Jin Bai, Yang Xiao, and **Chi-Min Shu**. 2018, "Effects on the activities of coal microstructure and oxidation treated by imidazolium-based ionic liquids", *Journal of Thermal Analysis and Calorimetry*. Volume 133, pp. 453–463 (SCI). IF: 2.731, Journal ranking: 18/61, Q2. (https://doi.org/10.1007/s10973-018-7310-z)

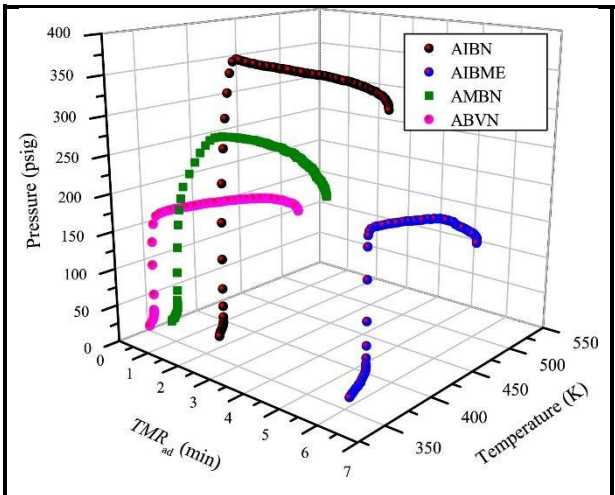
- Jun Deng, Yi Yang, Yan-Ni Zhang, Bo Liu, and **Chi-Min Shu**. 10/2018, “Inhibiting effects of three commercial inhibitors in spontaneous coal combustion”, *Energy*. Volume 160, pp. 1174–1185 (SCI). IF: 6.082, Journal ranking: 60/112, Q1. **(Corresponding Author)** (https://doi.org/10.1016/j.energy.2018.07.040)

Research topic H:

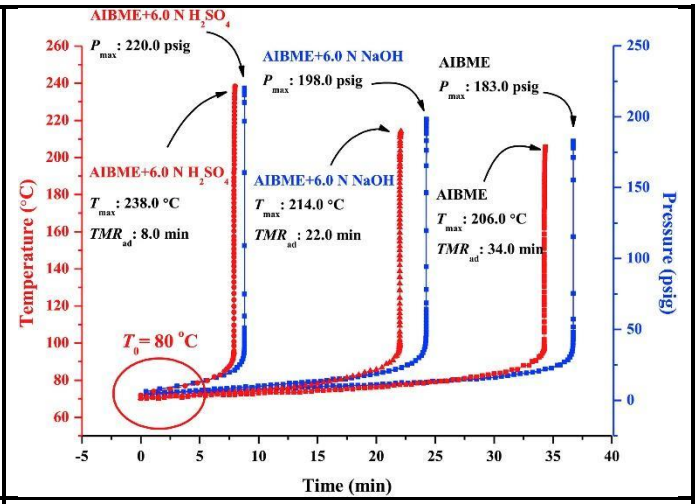
Deriving the reaction mechanism and determining a thermal hazard database for azo compounds.

Descriptions of the academic contributions

Azo compounds are ubiquitous and considered as important in various fields of sciences. Plastics and processing industry often add azo compounds as initiators and catalysts. Azo compounds possess exotic exothermic properties; however, the thermal hazard profiles of these compounds are not clearly revealed. In this research area, we formulated an innovative approach, and divulged the precise thermal degradation kinetics. Four azo compounds (AIBN, AMBN, ABVN, and AIBME) were selected, and three different calorimetric techniques were used to characterize the inherent hazard behaviors of azo compounds followed by non-linear optimization model analysis. These research findings could be the baseline studies of thermal hazards of azo compounds and helpful to design better loss prevention systems as an inherently safer design.



Pressure, temperature, and time to maximum rate under adiabatic conditions of the four azos by VSP2 tests.



Temperature and pressure vs. time for AIBME decomposition with mixed acidic or alkaline under the adiabatic condition.

Related publications

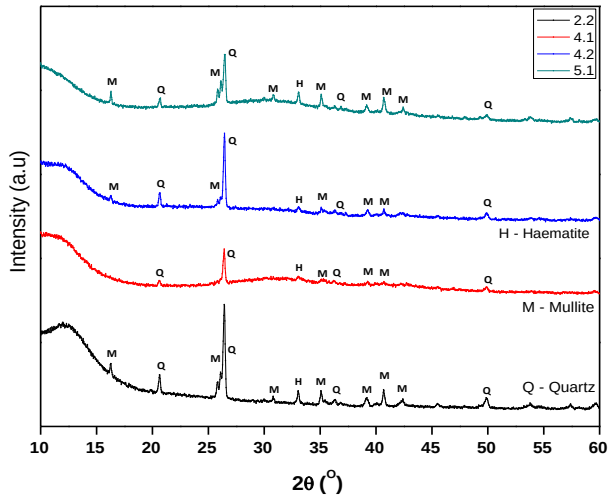
- Shang-Hao Liu, Chen-Rui Cao, Wei-Cheng Lin, **Chi-Min Shu**. 03/2019, "Experimental and numerical simulation study of the thermal hazards of four azo compounds", *Journal of Hazardous Materials*. Volume 365, pp. 164–177 (SCI). IF: 9.038, Journal ranking: 8/265, Q1. (https://doi.org/10.1016/j.jhazmat.2018.11.003)
- Chen-Rui Cao, Shang-Hao Liu, **Chi-Min Shu**. 03/2018, "Reaction simulation of multistage evaluations for AMBN based on DSC experiments", *Thermochimica Acta*. Volume 661, pp. 18–26 (SCI). IF: 2.762, Journal ranking: 17/61, Q2. **(Corresponding Author)** (https://doi.org/10.1016/j.tca.2018.01.009)
- Shang-Hao Liu, Wei-Cheng Lin, Hung-Yi Hou, and **Chi-Min Shu**. 09/2017, "Comprehensive runaway kinetic analysis and validation of three azo compounds using calorimetric approach and simulation", *Journal of Loss Prevention in the Process Industries*. Volume 49, pp. 970–982 (SCI). IF: 2.795, Journal ranking: 57/143, Q2. **(Corresponding Author)** (https://doi.org/10.1016/j.jlp.2017.05.014)

Research topic I:

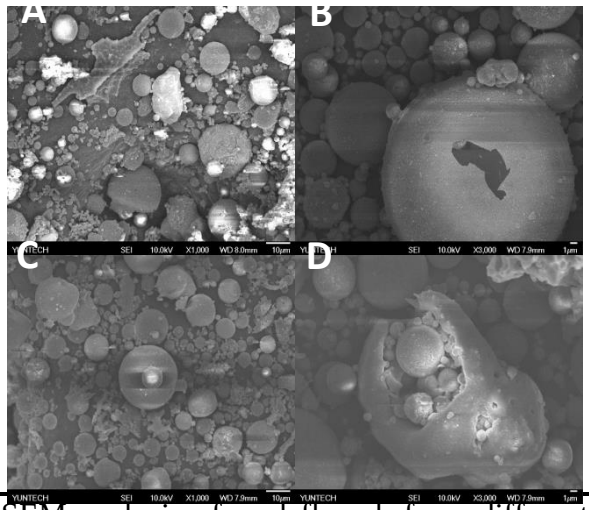
Synthesis of novel mesoporous materials for varied applications.

Descriptions of the academic contributions

The rapid surge of global energy needs has probed various new sources, but, the reliance on the coal-based energy has not altered significantly. This situation has resulted in expansive volumes of coal fly ash posing severe questions regarding the storage and disposal constraints. However, effective utilization rather than disposal has received a significant deal of attention from the past few decades. The present review portrays the impending applications of coal fly ash: In the synthesis of geopolymers also known as alternate cement, in the synthesis of aerogels (insulating materials), preparation of carbon nanotubes for electronic devices, and the extraction of rare earth elements. Further, the review analyzes the hiccups that decline the potential of coal fly ash. It discusses an effective management strategy via new product base of coal fly ash both in its raw and refined state. Moreover, it explains the role of coal fly ash as an emerging input in delivering eco-friendly amenities and future derivatives.



XRD analysis of coal fly ash from different demographical locations.



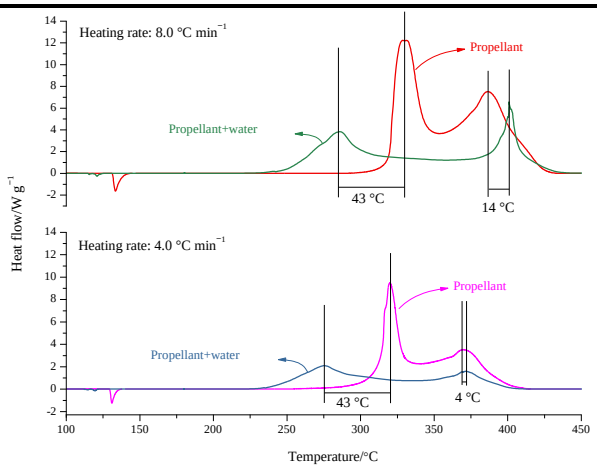
SEM analysis of coal fly ash from different demographical locations.

Related publications

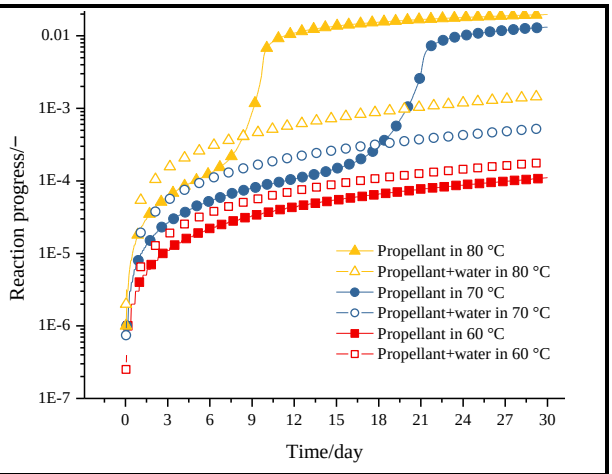
- A. R. K. Gollakota, Vikranth Volli, and **Chi-MinShu**. 04/2019, "Transesterification of waste cooking oil using pyrolysis residue supported eggshell catalyst" *Science of The Total Environment*. Volume 661, pp. 316–325 (SCI). IF: 6.551, Journal ranking: 22/265, Q1. (https://doi.org/10.1016/j.scitotenv.2019.01.165)
- Anjani RK Gollakota, Vikranth Volli, and **Chi-Min Shu**. 07/2019, "Progressive utilisation prospects of coal fly ash-A review" *Science of the Total Environment*. Volume 672, pp. 951–989 (SCI). **(Corresponding Author)** IF: 6.551, Journal ranking: 22/265, Q1. (https://doi.org/10.1016/j.scitotenv.2019.03.337)

Research topic J:
Thermal stability evaluation of fireworks by calorimetry approaches.

Descriptions of the academic contributions
Fireworks are constructed by powder and other materials which may release light and heat by oxidation reaction readily. Numerous accidents have occurred by using fireworks because pyrotechnic compositions are extremely sensitive to leading explosive decompositions. Thus, this study focused on the thermal stability of propellant, effect pieces, and propellant of multiple tubes mixed with water that were studied by differential scanning calorimetry and isoconversional kinetic analysis.



The shift of exothermic curves for wetted and dry propellant at two heating rates.

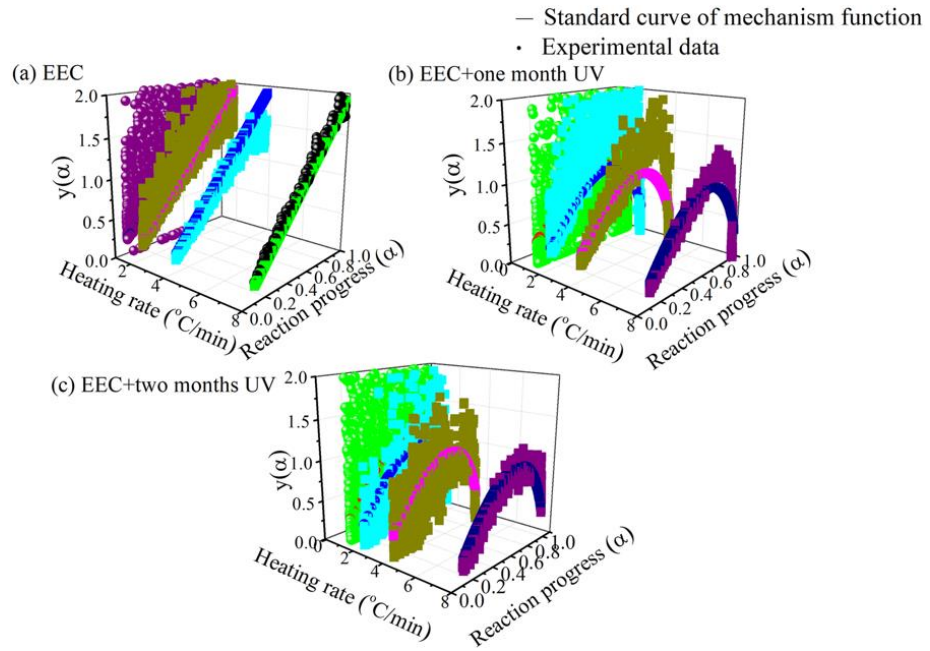


Predicted reaction progress of dry and wetted propellant for 30 days at 60, 70, and 80 °C.

Related publications
- Wei-Cheng Lin, Wei-Chun Chen, and **Chi-Min Shu.** 06/2019, "Thermal stability evaluation of multiple tubes of fireworks by calorimetry approaches", *Journal of Thermal Analysis and Calorimetry*. Volume 138, issue 4, pp. 2883–2890 (SCI). **(Corresponding Author)** IF: 2.731, Journal ranking: 18/61, Q2. (https://doi.org/10.1007/s10973-019-08496-y)

Research topic K:
Evaluating and researching the hazard of epoxy resin process and its use.

Descriptions of the academic contributions
Epoxy resin has been widely used in the fields of aviation, people's livelihood, building materials, etc. Practically speaking, it is the most widely used material at present. Epoxy resin plants have sporadically caused thermal accidents, and the tolerance of material strength is not enough to face the development of the aerospace industry. However, there have been only a few studies on the safety evaluation of epoxy resin. Therefore, it was necessary to proceed with this research for decreasing the risk.



Comparison of experimental curves and standard curves for EEC and EEC under prominent UV with different durations at one and two months by Málek model.

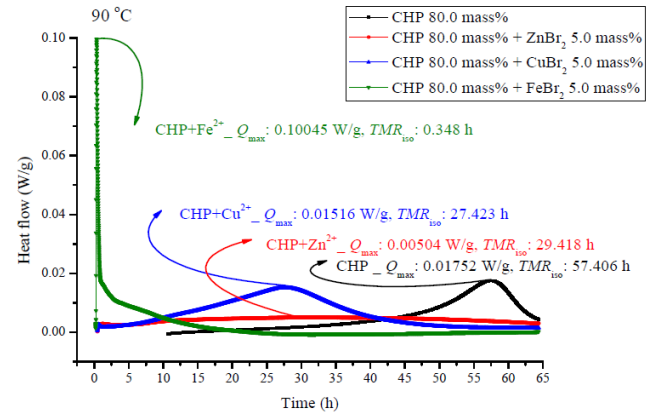
Related publications
- Bin Laiwang, Shang-Hao Liu, Yun-Ting Tsai, Jun Deng, Hui-Chun Jiang, Bei Li, and **Chi-Min Shu**. 10/2018, "Effects of UV for cycloaliphatic epoxy resin via thermokinetic models, novel calorimetric technology, and thermogravimetric analysis", *Scientific Reports*. (SCI). IF: 3.998, Journal ranking: 17/71, Q1. (https://doi.org/10.1038/s41598-018-34181-5)
- Yun-Ting Tsai, Sheng-Yi Lin, Jing-Wei Tong, Wei-Chun Chen, Wei-Ting Chen, and **Chi-Min Shu**. 05/2015, "Incompatible hazard investigation of a cycloaliphatic epoxy resin using green analytical method", *Journal of Thermal Analysis and Calorimetry*. Volume 122, pp. 1135–1141 (SCI). (**Corresponding Author**). IF: 2.731, Journal ranking: 18/61, Q2. (https://doi.org/10.1007/s10973-015-4771-1)
- Jing-Wei Tong, Wei-Chun Chen, Yun-Ting Tsai, Yan Cao, Jiann-Rong Chen, and **Chi-Min Shu**. 02/2014, "Incompatible reaction for (3–4–epoxycyclohexane) methyl–3'–4'–epoxycyclohexyl-carboxylate (EEC) by calorimetric technology and theoretical kinetic model", *Journal of Thermal Analysis and Calorimetry*. Volume 116, pp. 1445–1452 (SCI). (**Corresponding Author**). IF: 2.731, Journal ranking: 18/61, Q2. (https://doi.org/10.1007/s10973-014-3685-7)

Research topic L:

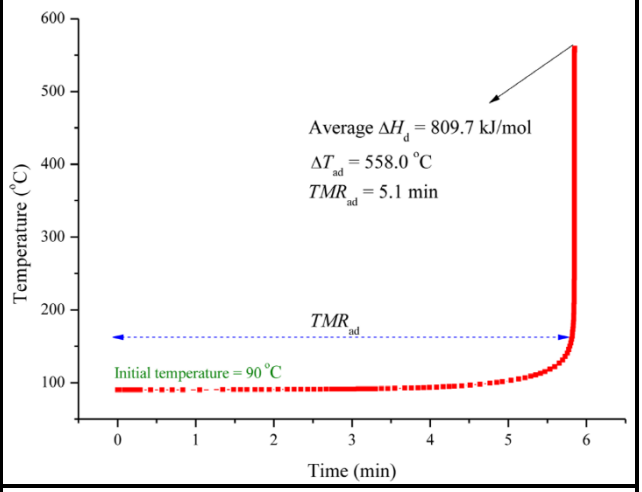
Reaction mechanisms and hazardous evaluation of metal containers and pipelines corrosion with reactants.

Descriptions of the academic contributions

The reactor tank, transit storage vessel, and pipeline used for manufacturing and transporting this substance are made of metal. Metal containers, which might release metal ions, used in chemical processes can be aged, worn, and erosive. This study discusses and elucidates the potential thermal hazard of a mixture of organic peroxide (OP) and an incompatible material's metal ions. Differential scanning calorimetry (DSC) and thermal activity monitor III (TAM III) were employed to preliminarily explore the thermal hazard at the constant temperature environment. The substance was diluted and analyzed by using a gas chromatography spectrometer (GC) and gas chromatography/mass spectrometer (GC/MS) to determine the effect of thermal cracking and metal ions of OP. The thermokinetic parameter values obtained from the experiments are discussed; the results can be used for designing an inherently safer process. As a result, various OPs have different incompatible metal ions, and further initiate runaway reactions.



Heat flow versus temperature plot for 80% CHP mixed with various metal ions tested using TAM III scanning analysis at 90 °C.



Evaluation of TMRad and ΔT_{ad} for 98 mass % TBPO mixed with one mass% $CuCl_2$ under adiabatic conditions.

Related publications

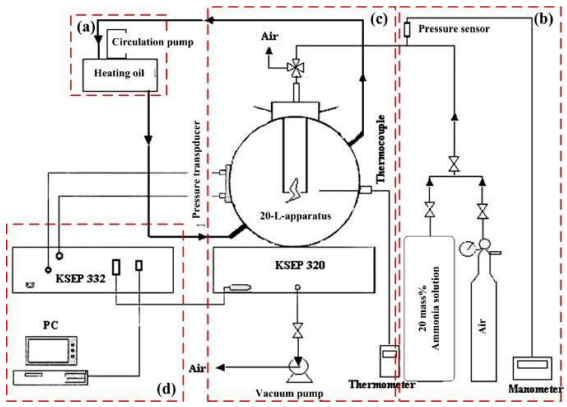
- An-Chi Huang, Wei-Chun Chen, Chung-Fu Huang, Jing-Yu Zhao, Jun Deng, and **Chi-Min Shu**. 11/2017, "Thermal stability simulations of 1,1-bis (tert-butylperoxy)-3,3,5 trimethylcyclohexane mixed with metal Ions", *Journal of Thermal Analysis and Calorimetry*. Volume 130, pp. 949–957 (SCI). IF: 2.731, Journal ranking: 18/61, Q2.
- Yun-Ting Tsai, Mei-Li You, Xin-Ming Qian, and **Chi-Min Shu**. 05/2013, "Calorimetric techniques combined with various thermokinetic models to evaluate incompatible hazard of tert-butyl peroxy–2–ethyl hexanoate mixed with metal ions", *Industrial & Engineering Chemistry Research*. Volume 52, pp. 8206–8215 (SCI). IF: 3.573, Journal ranking: 44/143, Q2.
- Lung-Chang Tsai, Mei-Li You, Mei-Fang Ding, and **Chi-Min Shu**. 07/2012, "Thermal hazard evaluation of lauroyl peroxide mixed with nitric acid", *Molecules*. Volume 17, pp. 8056–8067 (SCI). IF: 3.267, Journal ranking: 70/177, Q2.

Research topic M:

Elucidating the explosion characteristics of chlorodifluoromethane and isobutane at high temperature and pressure.

Descriptions of the academic contributions

Chlorofluorocarbons (CFCs) are used as a commercial refrigerant until the adoption of the Montreal Protocol on Substances that Deplete the Ozone Layer in 1989 (Montreal, 1987). CFCs were banned because they caused ozone layer depletion, consequently, CFCs were replaced by environmental refrigerants (ERs). However, ERs, such as R-600a, can cause fires and explosions under abnormal conditions. It should be stressed that the refrigerant R-22 (one of ERs) does not exhibit explosion behavior at normal pressure, but as increasing in the pressure to 10.0 bar, the explosion occurred at room temperature. Thus, the flammability of some ERs might change from non-flammable to an explosion with the increase of pressure. The research has provided useful information for safer refrigerant design for ERs at high pressure and temperature.

<table>
<tr>
<td> 
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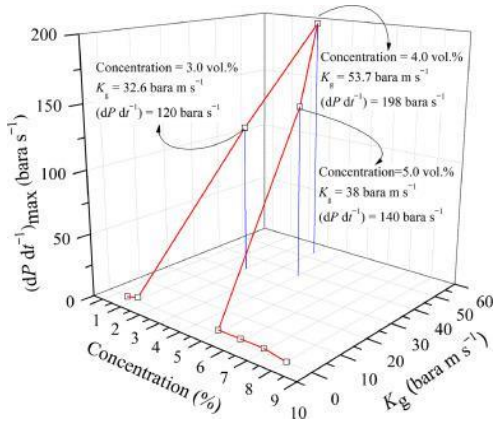
<td> 
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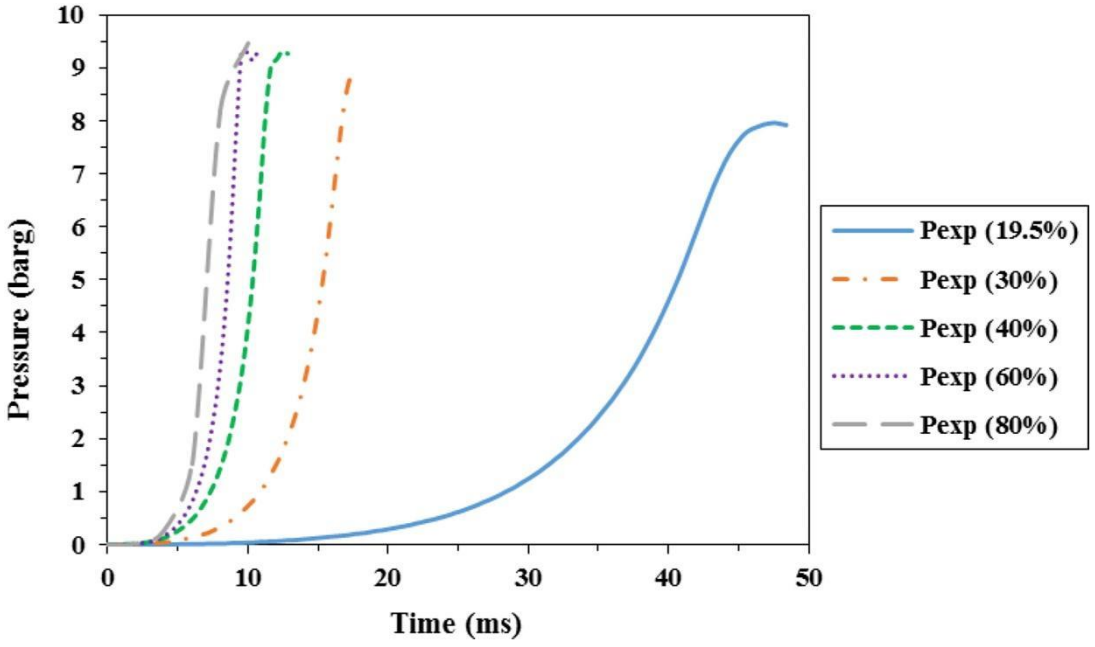
<tr>
<td>Schematic diagram of the experimental set-up and control system for 20-L apparatus.</td>
<td>3D diagram (Concentration–Kg–(dP dt^{-1})max) results for R-600a.</td>
</tr>
</table>

Related publications

- Yun-Ting Tsai, Jian-Yao Liao, **Chi-Min Shu**. 08/2019, "Corrigendum to 'Explosion characteristics of chlorodifluoromethane and isobutane at high temperature and pressure using a 20-L apparatus" *International Journal of Refrigeration*. Volume 104, pp. 501. (SCI). IF: 3.461, Journal ranking: 27/130, Q1. (Corresponding Author) (https://doi.org/10.1016/j.ijrefrig.2019.04.016)

Research topic N:
Explosion characteristics of flammable gas under the oxygen-enriched condition.

Descriptions of the academic contributions
The explosive properties of flammable gases under standard atmospheric conditions have been exhaustively studied. There are numerous processes in the industry that are carried out under oxygen-enriched conditions, but there are few studies related to explosions under these conditions. The results show that when the oxygen concentration is 19.5% and 30.0%, the explosion pressure rise curve is consistent with the theoretical formula. But at higher oxygen concentrations, the $(dP/dt)_{max}$ will be prominently underestimated. Therefore, in the future, in the oxygen-enriched process, the venting, suppression system, and isolation system should be reconsidered.

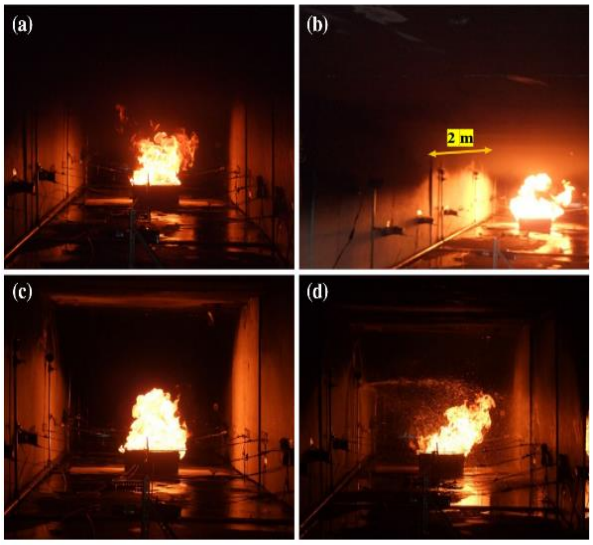


Explosion pressure rise curves of 6.5% ethylene gas under various oxygen concentrations.

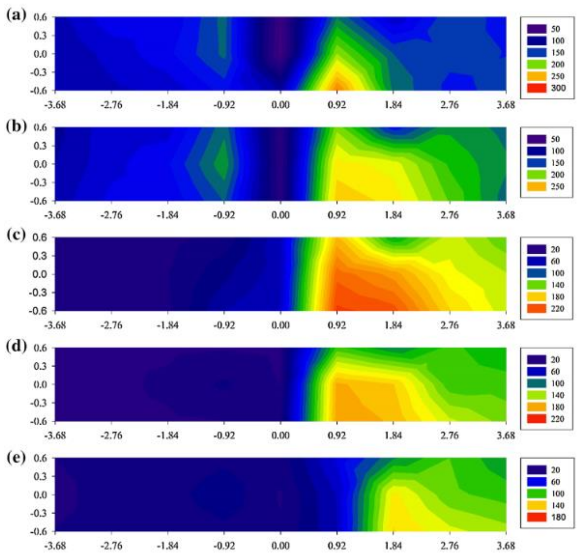
Related publications
- Chin-Feng Chen, **Chi-Min Shu,** Hong-Chun Wu, Hsin-Hsiu Ho, and San-Ping Ho, 09/2017, "Ethylene Gas Explosion Analysis Under Oxygen Enriched Atmospheres in A 20-Liter Spherical Vessel", *Journal of Loss Prevention in the Process Industries*. Volume 49, pp. 519–524 (SCI). IF: 2.795, Journal ranking: 57/143, Q2. (https://doi.org/10.1016/j.jlp.2017.05.022)

Research topic O:
Studying the interaction between the ventilation system and watering in tunnel fires.

Descriptions of the academic contributions
At present, eight new long tunnels are currently being constructed in Taiwan and plan to utilize sidewall sprinkler nozzles to conduct fire protection. The results showed that in the event of a tunnel fire, under the same supply wind speed conditions, if water mist is sprayed, the back layering will be saliently slowed down. It can be used as a design reference for fire sprinkler facilities in tunnels.



Flame propagation experiment with different air velocity and with or without water spray.



Ceiling gas temperature distribution with water spray under different velocities.

Related publications
- Yu-Jen Chen, **Chi-Min Shu**, San-Ping Ho, Hsiang-Cheng Kung, Shen-Wen Chien, Hsin-Hsiu Ho, and Wen-Sheng Hsu. 02/2014, "Analysis of smoke movement in the Hsuehshan tunnel fire", *Tunnelling and Underground Space Technology*. Volume 84, pp. 142–150 (SCI). IF: 4.450, Journal ranking: 10/134, Q1.
- Chin-Feng Chen, **Chi-Min Shu**, San-Ping Ho, Hsiang-Cheng Kung, and Shen-Wen Chien. 09/2017, "Effects of ventilation and water spray in a model-scale tunnel fire", *Fire Technology*. Volume 54, Issue 1, pp. 75–96 (SCI). IF: 1.671, Journal ranking: 50/91, Q3. (https://doi.org/10.1007/s10694-017-0673-z)
- Chen-Wei Chiu, Tony Lu, Hao-Ting Chao, and **Chi-Min Shu**. 02/2014, "Performance assessment of video–based fire detection system in tunnel environment", *Tunnelling and Underground Space Technology*. Volume 40, pp. 16–21 (SCI). IF: 4.450, Journal ranking: 10/134, Q1.

Research topic P:

Experimental and numerical investigation of the influence of laterally sprayed water mist on a methane-air jet flame.

Descriptions of the academic contributions

This study presented a novel experimental technique for suppressing a methane-air jet flame through lateral spraying with water mist. The mist's influence on the flame was evaluated to determine the combustion characteristics, such as the heat release rate, flame structure, radiation intensity, and extinguishing time. Moreover, a three-dimensional (3D) numerical simulation was employed to model the experimental conditions. The reported findings are anticipated to enhance the understanding of such processes and will be useful in developing water mist fire-suppression systems, improving the efficiency and widening the field of application of fire-suppression systems and fire-control systems more generally.

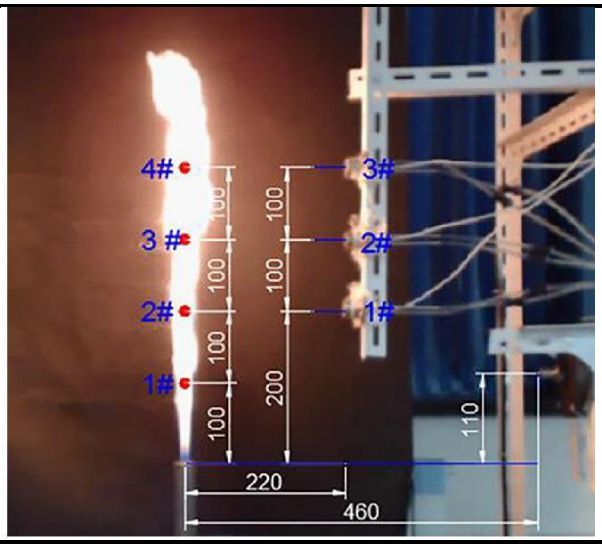
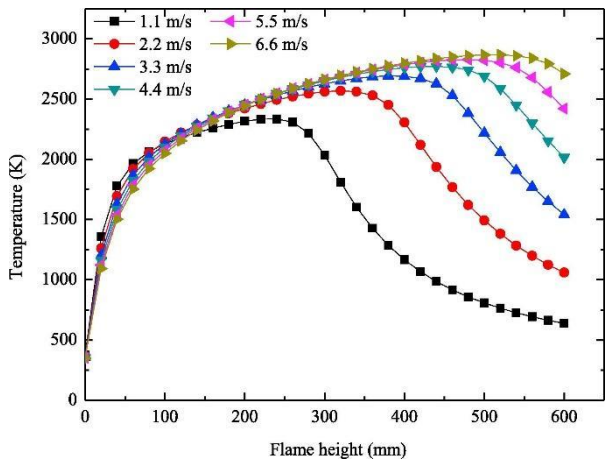


Diagram showing thermocouple and heat flowmeter measurement lo-cations concerning the spray nozzle.



In-flame temperature variation along flame centerline for the different gas velocities.

Related publications

- Haitao Li, Xiaokun Chen, **Chi-Min Shu**, Qiuhong Wang, and Yanni Zhang. 09/2018, "Experimental and numerical investigation of the influence of laterally sprayed water mist on a methane-air jet flame", *Chemical Engineering Journal*. Volume 356, pp. 554–569 (SCI). IF: 10.652, Journal ranking: 4/143, Q1. (https://doi.org/10.1016/j.cej.2018.09.051)

Research topic Q:

Prevention of green energy loss: Estimation of fire hazard potential in wind turbines.

Descriptions of the academic contributions

The thermal decomposition behavior and fire hazard of lubricating oil and transformer oil used in wind turbines were investigated by using a thermogravimetric analyzer with a non-isothermal model. Fourier transform infrared (FTIR) spectroscopy was added to analyze the functional group changes and decomposition processes of lubricating oils (hydraulic and gear oils) and transformer oils. Compared with previous studies, this study focused on thermochemical reactions occurring inside oils in various temperature ranges. The results demonstrated that the thermal decomposition process of the lubricating and transformer oils could be divided into three stages, with major mass loss occurring in the second stage. The heat flow increased with the temperature during thermal decomposition. The temperature associated with 17.5% mass loss can help to estimate the flash point, which in turn can help to detect the fire hazard potential of oils well on time. The FTIR results showed that during the oxidation of the transformer oil at sustained high temperature, it will produce the C=O of carbonyl compounds. The results of this study are conducive to the discovery of safety hazards inherent in the oil and provide a basis for timely replacement of oil in wind turbines.

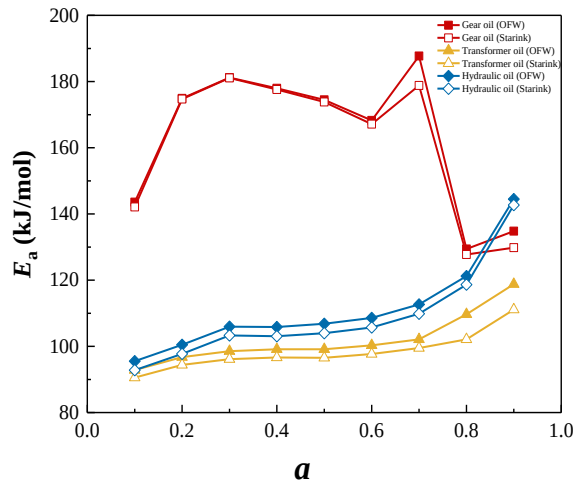
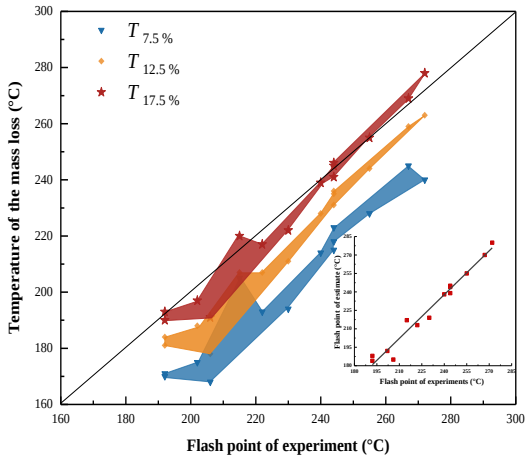


Diagram showing relationship between the activation energy and the conversion for oils.



Relationship of the experiments and estimate in flash point for oils.

Related publications

- Wei Sun, Wei-Cheng Lin, Fei You, **Chi-Min Shu**, and Sheng-Hui Qin. 2019, "Prevention of green energy loss: Estimation of fire hazard potential in wind turbines" *Renewable Energy*. Volume 140, pp. 62–69 (SCI). **(Corresponding Author)** IF: 6.274, Journal ranking: 19/112, Q1. (https://doi.org/10.1016/j.renene.2019.03.045)