PURDUE PROCESS SAFETY AND ASSURANCE CENTER (P2SAC):

INTRODUCTION, STATUS, AND AGENDA

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HISTORY OF P2SAC

- **Concept of P2SAC: Presentation by Basaran to ChE faculty at school retreat on 5/2013**
- **Conception and birth of center: Following extensive interactions with and input from industry (12/2013)**
- **Inaugural conference and official launch of P2SAC: Monday, October 13, 2014**
- **History of industry membership in P2SAC:**
  - **Spring 2014: Honeywell, BP, ExxonMobil (3 members)**
  - **…**

HISTORY AND STATUS OF P2SAC

- **History of and current industry membership in P2SAC:**
  - **Spring 2014: Honeywell, BP, ExxonMobil (3 members)**
  - **Summer/Fall 2014: Honeywell, BP, ExxonMobil, and Eli Lilly (4 members)**
  - **Spring/Fall 2015: Honeywell, BP, ExxonMobil, Eli Lilly, and Shell (5 members)**
  - **Fall 2016: Honeywell, BP, ExxonMobil, Eli Lilly, Shell, and Chevron (6 members)** ***[Ray Mentzer joins P2SAC]***
  - **Spring 2017: Honeywell, BP, ExxonMobil, Eli Lilly, Shell, Chevron, Dow, Phillips 66, and Kenexis (9 members)**
  - **Spring 2018: Honeywell, BP, ExxonMobil, Eli Lilly, Shell, Chevron, Dow, P66, Kenexis, Fauske, and Amgen (11 members)**
  - **Fall 2018: Honeywell, BP, ExxonMobil, Eli Lilly, Shell, Chevron, Dow, P66, Kenexis, Fauske, Amgen, 3M, Pfizer, and GSK (13 members)**

REMEMBERING THE P2SAC INAUGURAL CONFERENCE

- **Date: Monday, October 13, 2014**
- **Location: FRNY Hall of ChE**
- **Who was there: Honeywell, BP, ExxonMobil, Eli Lilly, Air Products, and about ten Purdue ChE faculty plus a few graduate students (*fewer than 20 people*)**
- **What was the agenda: much more modest than what we shall see today!**

WHY A PURDUE SAFETY CENTER AND WHAT ARE ITS UNIQUE FEATURES?

- There are very few such centers, e.g. Mary Kay O'Connor (MKO) Safety Center at TAMU (focus is mostly on petrochemical industry).
- Representatives of member companies on the School of Chemical Engineering's Industrial Advisory Committee (IAC), i.e. many of your peers/colleagues, report that only a small fraction of the needs of industry in the safety arena is met by existing academic centers.
- It was and continues to be strongly recommended by members of the IAC and other colleagues from industry that the Purdue Center should also focus on **process and/or product assurance**---the reason the center was/is named the ***Purdue Process Safety and Assurance Center*** (**P2SAC**).
- The approach adopted at P2SAC, while **driven by problems in industry**, would be/is **research-based**. We leave more applied safety issues, e.g. the training of first responders, to others.

Purdue Process Safety and Assurance Center (P2SAC)

We all understand the **safety** part!

(See next few slides.)

Plant Explosion Tears at the Heart of a Texas Town

By MANNY FERNANDEZ and JOHN SCHWARTZ
Published: April 18, 2013 (New York Times)

WEST, Tex. — The blast was so powerful that the United States Geological Survey registered it as a 2.1-magnitude earthquake. It reduced an apartment complex to a charred skeleton, leveled homes in a five-block radius and burned with such intensity that railroad tracks were fused. It killed up to 15 people and injured up to 180. Volunteer firefighters were missing. Residents of a nursing home were pulled from debris and rushed to hospitals.

By Thursday evening, one day after a fertilizer plant here caught fire and then exploded, no one among the hundreds of local, state and federal officials and first responders who converged on this town north of Waco was certain about the cause. They only knew its effect.

The Texas Fertilizer Plant Explosion

By Mike Elk, Published: April 23 (Washington Post)

Mike Elk is a labor reporter and staff writer for In These Times Magazine.

Erich Schlegel/Getty Images - WEST, TX - APRIL 18: The remains of an apartment complex next to the fertilizer plant that exploded on April 17, 2013 in West, Texas. Around 14 people, including 10 first responders, were killed and more than 150 people were injured. (Photo by Erich Schlegel/Getty Images)

From the New York Times (April 19, 2013)

Larry W. Smith/European Pressphoto Agency

The remains of the plant. The authorities say there is no indication of criminal activity in the explosion, which followed a fire.

Accidents and safety

Accidents not only result in the tragic loss of human lives, damage to property and infrastructure, and financial loss but also reduce confidence among the population in industry as well as add to the general and unfortunately growing mistrust in technology, engineering, and science.

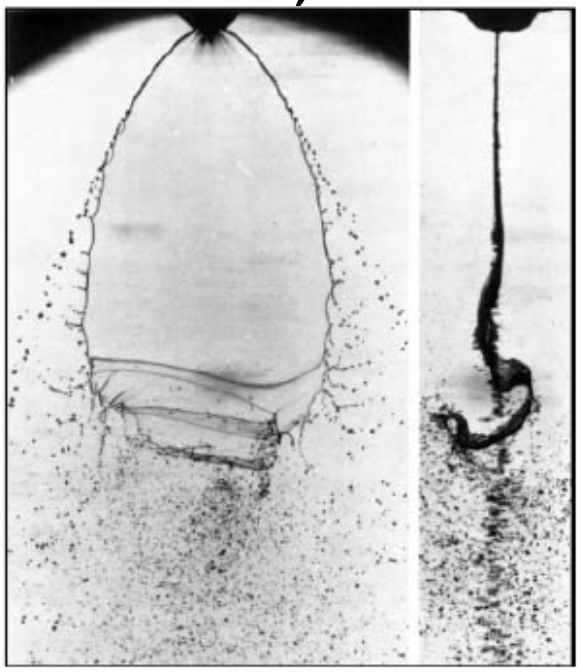
Purdue Process Safety and Assurance Center (P2SAC)

What is and why **assurance**?

(See next few slides.)

Why Assurance? Spray drift example from crop spraying or crop protection

Liquid sheet from a fan spray nozzle (Crapper et al. JFM 1973; Villermaux ARFM 2007, Altieri and Cryer 2018)



Small drops are undesirable because they lead to drift (Basaran group research funded by Dow Agrosciences/ Corteva)

Spray drift is the most common cause of off-target movement of chemicals (e.g. pesticides) in crop spraying. It can injure or damage plants, animals, the environment or property, and even affect human health. "Drift" is the airborne movement of agricultural chemicals as droplets, particles or vapor.

Nonstandard Inkjets

Annu. Rev. Fluid Mech. 2013. 45:85–113

Osman A. Basaran,[1] Haijing Gao,[1,2] and Pradeep P. Bhat[1,3]

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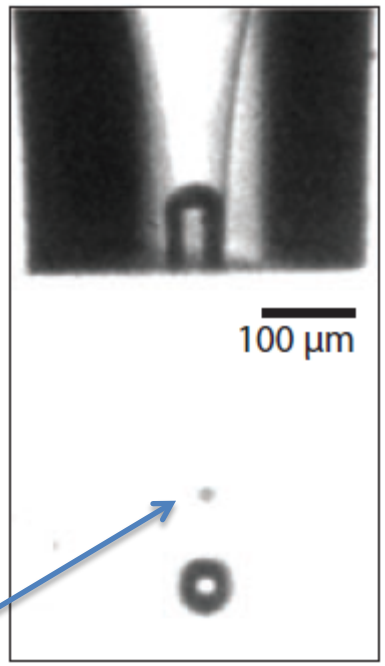
*Production of **monodisperse drops** and prevention of undesirable satellites are also key **flow assurance** issues in **ink jet printing** and **drop-wise (drop-based) manufacturing (e.g. personalized medicine)***

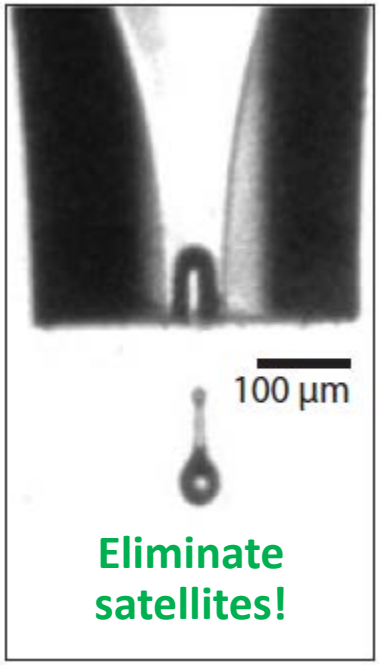
Pharma!

Squeeze-mode piezo sleeve and 35 µm glass nozzle used in DNA microarraying and other cutting edge applications

"Standard" waveform and "big" drops (plus *undesirable satellites*!)

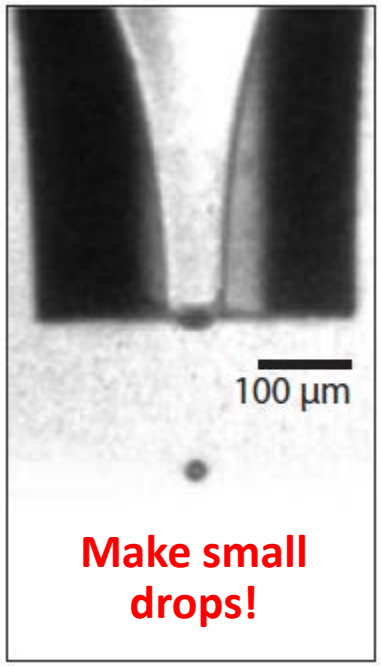


"Standard"



Eliminate satellites!

"New and better"



Make small drops!

"New and best"

"Novel" waveform(s) invented at Purdue make "small" drops (we can use nozzles from a 1984 HP Thinkjet to make drops as small as is possible with today's printers!)

Examples of flow assurance

- Coalescers, dehydrators, desalters, and oil-water separators (widely used in the oil & gas industry)*
- Hydrate formation in oil and gas pipelines#
- Spray drift in agriculture*
- "Drop size-modulation" and "satellite droplet or misting prevention" in ink jet printing and other drop-wise or additive manufacturing operations*
- Rupture/integrity of coated films on substrates*
- Rupture of free thin films/sheets (important in atomization and polymer processing)*

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*Studied in the Basaran group

Studied in the Corti and Franses groups

Center vision

- The goal of the Purdue Process Safety and Assurance Center (P2SAC) is to become the world-wide center-of-excellence in research, education, and service in safety as well as process and product assurance
- The aim of P2SAC is to carry out research to address and solve problems having applied as well as fundamental importance in the safe and reliable operation of industrial processes in diverse fields
- However, P2SAC does not deal in non-research-intensive activities such as the training of first responders
- Work in P2SAC is and will continue to be quite **broad** but be **focused** on the ***energy, chemical, petrochemical, and pharmaceutical industries*** (among others, **e.g. agriculture**)

Center activities

- Involve multiple faculty (rather than a single person), PhD students (2+ year projects), Professional MS students (intense summer projects mentored by member companies), and exceptional undergraduates (mostly mentored by Ray Mentzer) in safety-related research
- Additionally, P2SAC aims to become a leader in safety education through development and teaching of undergraduate, graduate, and other types of courses (*According to informal/unscientific polling of first year graduate students in our program in 2017,* ***Purdue ChE is one of three departments nationally and internationally*** *that requires all undergraduates to take a core course on safety in order to receive a BS degree*) *(The course is also offered to graduate students, which is even more unusual.)*

Member company benefits

- Attendance at the annual program review and technical conferences (one in the spring and the other in the fall)
- Helping to determine and identify projects to be funded and research areas to be pursued *and* guiding projects
- Direct involvement with P-MS students, i.e. mentoring
- Early access to research findings
- “Royalty-free” use of (some) PhD research findings
- Increased access to uniquely trained graduate students (PhD as well as MS) and postdocs, in addition to undergraduate students, as *permanent hires* and/or *interns*
- Direct participation in the Center’s research programs via the *technical fellows program*

Select examples of outreach to member and potential member companies

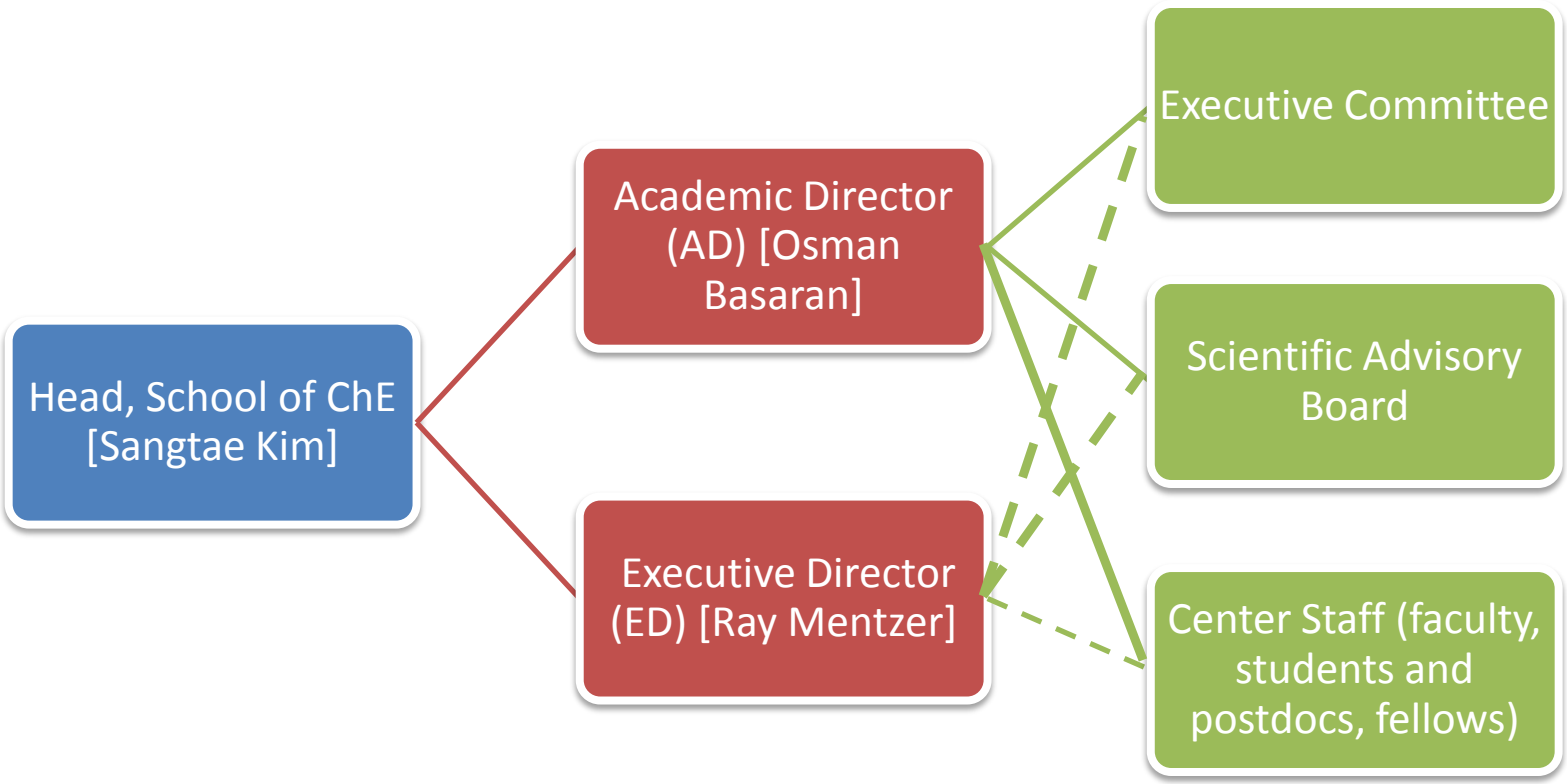
- Professors Carl Laird and Osman Basaran attended and delivered presentations at the Lilly Global Process Safety Conference on August 24, 2018, in Indianapolis, IN.
- Osman Basaran visited 3M and gave a seminar on May 31, 2018, in St. Paul, MN, to generate interest in the assurance side of P2SAC.
- Osman Basaran visited Dow Agrosciences to make a presentation on flow assurance, spray drift, and crop protection systems on July 20, 2018, in Indianapolis, IN.
- Other examples will be provided by Ray Mentzer.

P2SAC Organization by Sectors

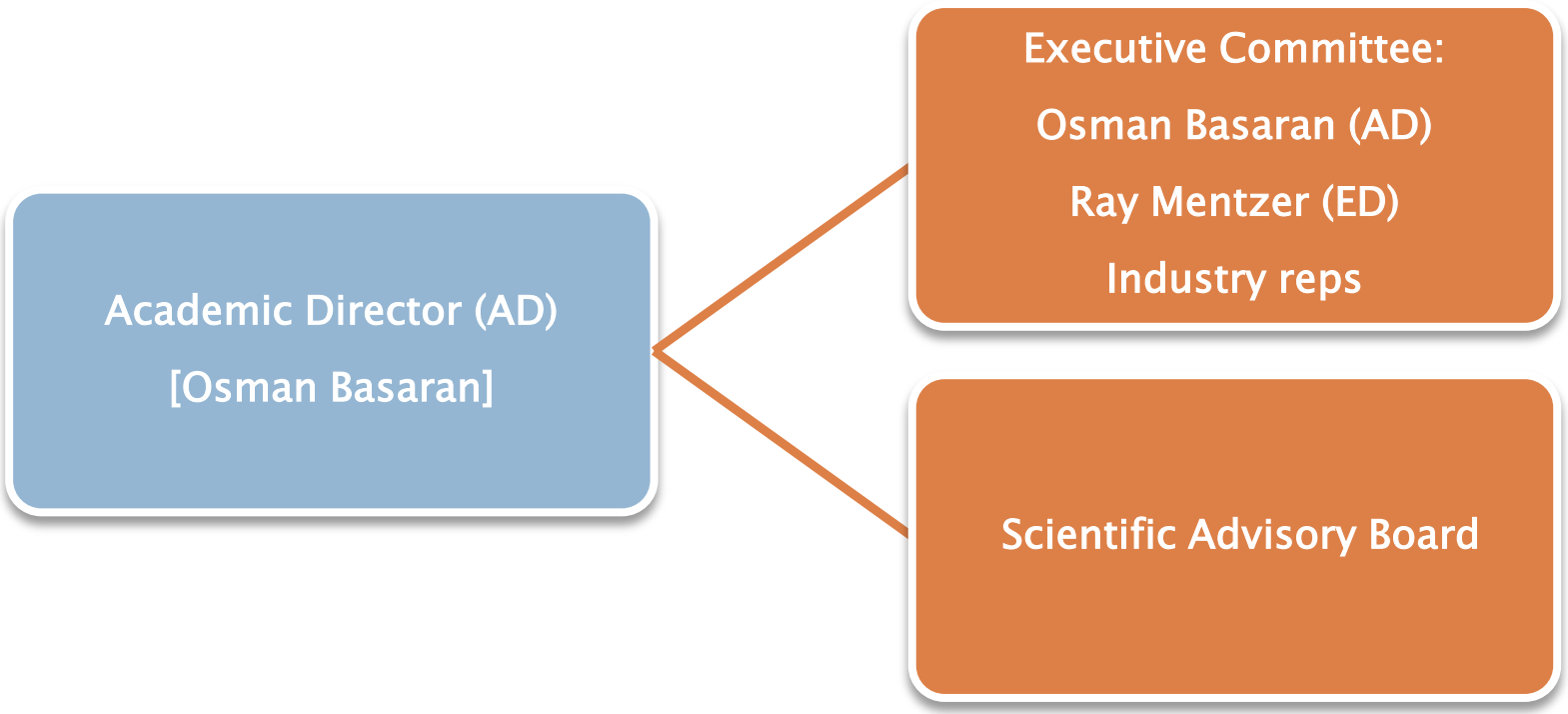
- Oil, gas, and petrochemicals
- Chemicals
- Technology, including consumer products and diversified manufacturing
- Pharmaceuticals (a growth area)
- Future: focus especially on developing “agriculture” while continuing to grow pharma and other areas

Bring people together from different industries, backgrounds, and interests who normally would not interact with one another with the goal of creating synergisms that may not arise under ordinary circumstances

P2SAC Organizational Chart



P2SAC organization for setting research and funding priorities



Scientific Advisory Board

- **George Harriott, Air Products** (safety and consequence analysis/modeling)
- **Jonathan Bach, NIOSH/CDC** (PTD)
- **Prasad Goteti, Honeywell** (quantitative risk analysis)
- TBD (pharma)
- **Hari Subramani, Chevron** (flow assurance, oil and gas)
- TBD (flow assurance, other)

Three conferences for May 2019

- May 7: ***Pharma*** (organized by Ray Mentzer)
- May 8: ***"Regular" P2SAC spring 2019 conference***
- May 9: ***Flow assurance*** (organized by Osman Basaran)

Acknowledgements

- I thank all of you who have taken the time out from your busy schedules to be here.

- I would also like to say a big thank you to **Lauren Hays**, my EA, who has taken care of all the small and big logistical details to ensure that the Fall 2018 Conference of P2SAC runs smoothly. Special thanks are also extended to Joshua Gonzalez, Melissa Schwartz, and Jason Thorp for helping out in innumerable ways during the conference.

PURDUE PROCESS SAFETY AND ASSURANCE CENTER (P2SAC)
AGENDA FOR FALL 2018 CONFERENCE

Tuesday, December 11 (day prior to the conference)

6:00 pm **Pre-conference dinner and discussion** (Industrial members, guests, faculty, students, and postdocs)
5th Floor Mingling Room at Ross Ade Stadium (park in lot outside venue)

Wednesday, December 12, Wilmeth Active Learning Center, B058 (new venue!)

7:15-7:45 **Coffee, tea, and light snacks**

Session 1: Welcome and Introduction to P2SAC

7:45-8:00 **Osman Basaran** (Professor of ChE and Academic & Founding Director P2SAC, Purdue): Welcome, what is P2SAC, and agenda

8:00-8:20 **Ray Mentzer** (Visiting Professor of ChE and Executive Director P2SAC, Purdue): Report on broadening number and scope of P2SAC projects via PhD, MS, and UG student participation and industry mentoring; update on dual-level course on process safety management; new P2SAC initiatives and activities

Session 2: Quantitative and Simulation-Driven Approaches to Process Safety (Moderator: O. Basaran)

8:20-9:05 **Carl Laird** (Professor of ChE, Purdue): Part 1: Systems engineering and optimization techniques for improved safety and security of critical infrastructure and process industries. Part 2: Gas detector placement in petrochemical and chemical facilities.

9:05-9:45 **George Harriott** (Air Products): Leak detection on gas pipelines

9:45-10:00 **Sai Swetha Sathanapally** (ChE PMP student, Purdue): Characterization of reactive chemical hazards via calorimetry

10:00-10:15 Coffee and snack break

Session 3: Improving Process Safety (Moderator: R. Mentzer)

10:15-10:50 **Raj Gounder** (Professor of ChE, Purdue): Prevention through catalyst design for applications in the petrochemical industry

10:50-11:20 **Stewart Behie** (Occidental): Driving PSM performance beyond KPI metrics

11:20-11:50 **Laurence Pearlman** and **Gabe Onofre** (Marsh Risk Consulting): Process safety and the front line – How to simplify PS learning and establish safety critical equipment as a priority

11:50-12:15 **Tony Downes** (Honeywell): Trust, but verify - the case for placing the entire safety lifecycle in one accessible place

12:15-12:55 Catered lunch for participants (industrial reps, faculty, graduate and undergraduate students, and other guests)

Session 4: Broad Applications of Process Safety and Flow Assurance (Moderator: O. Basaran)

12:55-1:20 **Han Xia** (Eli Lilly): Identifying autocatalytic decomposition reactions using model free kinetics

1:20-1:45 **Jay Deveraj** (Dow Agrosciences): Improving R&D and academic lab safety through management of change and training

1:45-2:05 **Arvind Varma** (Professor of ChE, Purdue): Parametric sensitivity and thermal runaway behavior in catalytic fixed-bed reactors

2:05-2:20 **Joseph Pekny and James Dietz** (Professors, Purdue): Cybersecurity initiative with CISTAR

2:20-2:35 **Ed Marszal** (Kenexis): PMP project data structure standardization for PHA

2:35-2:45 **Zoltan Nagy** (Professor of ChE, Purdue): Overview of continuous pharmaceutical manufacturing

2:45-2:55 **Linda Wang** (Professor of ChE, Purdue): Overview of efficient and safe separations and solvents

2:55-3:05 **Osman Basaran** (Professor of ChE, Purdue): Overview of coalescence and flow assurance

3:05-3:15 Refreshment break (but continue into next session)

Session 5: Open Discussion to be led by Industrial Representatives (Moderators: R. Mentzer and O. Basaran)

3:15-5:10 Open discussion and needs led by industry reps (10 minutes per large member company, 5 minutes per small member company, and plus 15 minutes total to potential new members)

Session 6: Pitches for New PhD Projects (Moderators: O. Basaran and R. Mentzer)

5:10-6:00 Short pitches by faculty for new PhD projects (~5 minutes per single projects; ~7.5 minutes per multiple projects)

6:00 Adjournment (dinner to follow---see below)

6:30 pm **After conference dinner and discussion** (Executive Committee only)
Location: Bistro 501, Lafayette

Pitches by faculty for new projects in P2SAC during Fall 2018 Conference on December 12

Raj Gounder: New directions in prevention by catalyst design

Arvind Varma: Catalyst design and reactor runaway: selective oxidation of alcohols

Brett Savoie: Molecular property prediction based on scarce data using a novel machine learning framework

Brett Savoie: High-throughput quantum chemical calculation of Benson group values for reliable thermodynamic characterization

Zoltan Nagy: Modeling and uncertainty analysis of dust explosion

Kingsly Ambrose: Sensing dust concentration by imaging

Letian Dou: Safer materials and processing design for next-generation printed electronics

Vilas Pol: Battery safety by materials design

Carl Laird: Optimal placement of detectors and new directions driven by systems engineering approaches

Osman Basaran: Electrocoalescence: breaking emulsions, oil-water separators, desalters, dehydrators, and more