We will begin momentarily at 2pm ET.

Slides available now! Recordings will be available to ACS members after one week.

www.acs.org/acswebinars

Contact ACS Webinars ® at acswebinars@acs.org

Have Questions?

“Why am I muted?”
Don’t worry. Everyone is muted except the presenter and host. Thank you and enjoy the show.

Type them into questions box!

Contact ACS Webinars ® at acswebinars@acs.org
Have you discovered the missing element?


Find the many benefits of ACS membership!

Benefits of ACS Membership

Chemical & Engineering News (C&EN)
The preeminent weekly news source.

NEW! Free Access to ACS Presentations on Demand®
ACS Member only access to over 1,000 presentation recordings from recent ACS meetings and select events.

NEW! ACS Career Navigator
Your source for leadership development, professional education, career services, and much more.

Let’s get Social…post, tweet, and link to ACS Webinars during today’s broadcast!

facebook.com/acswebinars

@acswebinars

Search for “acswebinars” and connect!

How has ACS Webinars® benefited you?

“ACS Webinars broaden my chemical technology knowledge database. This is sometimes very useful since I work as a chemical technology consultant for my employer.”

Fan of the Week

Jack Horvath,
Senior Chemist, HydroChem LLC

Be a featured fan on an upcoming webinar! Write to us @ acswinbina@acs.org
Learn from the best and brightest minds in chemistry!
Hundreds of webinars presented by subject matter experts in the chemical enterprise.

Recordings are available to current ACS members one week after the Live broadcast date. www.acs.org/acswebinars

Broadcasts of ACS Webinars® continue to be available to the general public LIVE every Thursday at 2pm ET!

www.acs.org/acswebinars
Upcoming Events:

• Northeast Regional Discussion Group (NERDG) Annual Meeting – April 19th, Farmington CT (http://aaps-nerdg.org/)

• Contemporary Perspectives on Developing Amorphous Pharmaceuticals (Arden Conference) – April 18th to 20th, Baltimore MD (http://www.aaps.org/Arden/)  

• National Biotechnology Conference (NBC) – May 16th to 18th, Boston MA (http://www.aaps.org/nationalbiotech/)

2016 Drug Design and Delivery Symposium

Upcoming ACS Webinars®
www.acs.org/acswebinars

Thursday, April 7, 2016
Chemistry of Go: Innovations in Alternative Fuels
Session 4 of the 2016 Material Science Series
Jennifer Holmgren, Chief Executive Officer, LanzaTech
Mark Jones, Executive External Strategy and Communications Fellow, Dow Chemical

Thursday, April 14, 2016
Creating a Stand Out Professional Development Plan
Dorie Clark, Author and Marketing Strategy Consultant, Clark Strategic Communications, Inc.
John Mihalick, Strategic Accounts Manager, ACS Professional Advancement

Contact ACS Webinars® at acswebinars@acs.org

2016 Drug Design and Delivery Symposium
“Modified Release Formulations for Solubility Starved Compounds”

Slides available now! Recordings will be available to ACS members after one week
www.acs.org/acswebinars

The 2016 DDDS is co-produced with ACS Division of Medicinal Chemistry and the AAPS
Presentation Outline

• Introduction
  – Overview of oral modified release (MR) formulations
  – Solubility of API

• Challenges of MR formulation development with insoluble compounds

• Strategies used in MR formulations to ensure consistent drug release and absorption of insoluble compounds
  – Improve API solubility/dissolution
  – Selection of MR formulations

• Case studies

• Summary
Overview of Oral Modified Release (MR) Formulations – Delivery Design

- Oral modified release formulations are intended to improve the performance of immediate release products by modifying release rate, site or time.

**Delayed Release**
- To avoid degradation, metabolism or irritation
  - • Enteric coating for acid labile or gastric irritating compounds
  - • Colonic delivery to avoid metabolism in the gut
- Target delivery to disease site
  - • For example: delayed release formulation for treating colitis
- For chronotherapy
  - • Maximize efficacy and avoid adverse effect by matching drug release with body’s natural rhythms and cycles

**Sustained Release**
- To overcome short half-life issues
  - • Maintain plasma concentration above efficacious level at all time
  - • Avoid high peak plasma concentration to ensure safety
  - • Convenience and improve patient compliance by reduce dosing frequency

Overview of Oral Modified Release (MR) Formulations – Formulation Technologies

- Monolithic matrices
  - Hydrophilic matrix
    - Erosion and Diffusion
  - Inert matrix
    - Fluid penetration, Dissolution and Diffusion

- Simple reservoir systems
  - Drug diffuses through the coating layer or drug is released after erosion of the coat

- Push-pull osmotic pumps
  - Drug layer
    - Push layer
    - Semi-permeable coating

- Ion-exchange resin approaches
  - Styrene and divinylbenzene
    - SO₃⁻
  - Methacrylic acid and divinylbenzene
    - COO⁻
  - Styrene and divinylbenzene
    - NH₃⁺ or NH₄⁺
Solubility

- **Description of Solubility**
  - USP
  - BCS classification
    - Can the dose be solubilized in 250 mL of aqueous buffers, pH 1.0 to 7.5?
  - Dose/solubility ratio
    - Whether solubility is adequate depends on the dose
  - Other considerations
    - pH dependency
    - Tendency to stay oversaturated

- **Dose/solubility ratio**
  - Whether solubility is adequate depends on the dose

- **Cause of low solubility:**
  - High crystallinity or hydrophobicity

### Solubility Table

<table>
<thead>
<tr>
<th>Descriptive Term</th>
<th>Parts of Solvent Required for 1 Part of Solute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very soluble</td>
<td>Less than 1</td>
</tr>
<tr>
<td>Freely soluble</td>
<td>From 1 to 10</td>
</tr>
<tr>
<td>Soluble</td>
<td>From 10 to 30</td>
</tr>
<tr>
<td>Sparingly soluble</td>
<td>From 30 to 100</td>
</tr>
<tr>
<td>(33 mg/mL to 10 mg/mL)</td>
<td></td>
</tr>
<tr>
<td>Slightly soluble</td>
<td>From 100 to 1,000</td>
</tr>
<tr>
<td>(10 mg/mL to 1 mg/mL)</td>
<td></td>
</tr>
<tr>
<td>Very slightly soluble</td>
<td>From 1000 to 10,000</td>
</tr>
<tr>
<td>(1 mg/mL to 0.1 mg/mL)</td>
<td></td>
</tr>
<tr>
<td>Practically insoluble</td>
<td>≥10,000</td>
</tr>
<tr>
<td>or insoluble</td>
<td>(&lt;0.1 mg/mL)</td>
</tr>
</tbody>
</table>

**Cause of low solubility:**
- High crystallinity or hydrophobicity

---

**Audience Survey Question**

Do you think the compounds in the pharmaceutical pipeline are trending more or less soluble compared to the marketed products?

- More soluble
- Less soluble
- About the same
Audience Survey Question

Do you think the compounds in the pharmaceutical pipeline are trending more or less soluble compared to the marketed products?

- More soluble
- Less soluble
- About the same

The Innovator Pipeline Predominantly Contains Low Solubility Drugs

- BCS II and IV compounds present 90% of the industry pipeline
- Solubilization technologies are critical to the pharmaceutical industry to develop insoluble compounds into efficacious products

Adapted from: Lipp, R., American Pharmaceutical Review, April 30, 2013
Challenges of MR Formulation Development For Insoluble Compounds

- Insoluble compounds, by nature, have extended release properties due to limited dissolution rates.
  - Frequently associated with PK variability and food effects
  - Display solubility limited absorption and low bioavailability due to insufficient GI transit time to dissolve the whole dose.

- MR formulations, different from IR formulations which are mainly absorbed in the upper GI tract, usually rely on absorption in the lower GI tract

Environment of lower intestine
- pH in the human GI tract

<table>
<thead>
<tr>
<th>Location</th>
<th>Average pH (Fasted)</th>
<th>Average pH (Fed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stomach</td>
<td>1.3</td>
<td>4.9</td>
</tr>
<tr>
<td>Duodenum (mid-distal)</td>
<td>6.5</td>
<td>5.4</td>
</tr>
<tr>
<td>Jejunum</td>
<td>6.6</td>
<td>5.2-6</td>
</tr>
<tr>
<td>Ileum</td>
<td>7.4</td>
<td>7.5</td>
</tr>
<tr>
<td>Colon</td>
<td>6.4-7</td>
<td>≈6.5</td>
</tr>
</tbody>
</table>

- Composition: lower bile salts
- Less absorption surface area, lack of villi in colon
- Less unbound water
- Complex transition through ascending colon
- Bacteria flora

Early MR Feasibility Assessment and Risk Evaluation in Discovery and Early Development

<table>
<thead>
<tr>
<th>Compound Attributes</th>
<th>Target Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacokinetic properties</td>
<td></td>
</tr>
<tr>
<td>Predicted human half-life</td>
<td>≥6 h</td>
</tr>
<tr>
<td>Good bioavailability using a simple solution</td>
<td></td>
</tr>
<tr>
<td>Linear exposure dependence on dose preferred</td>
<td></td>
</tr>
<tr>
<td>≥20%</td>
<td></td>
</tr>
<tr>
<td>Physicochemical characteristics</td>
<td></td>
</tr>
<tr>
<td>Dog colonic absorption as a solution (relative to oral)</td>
<td>≥60%</td>
</tr>
<tr>
<td>API solubility</td>
<td>Dose/solubility &lt;100 mL</td>
</tr>
<tr>
<td>Stability</td>
<td>Chemically and physically stable API form</td>
</tr>
</tbody>
</table>

**100 mg dose → Solubility: >1 mg/mL**
**10 mg dose → Solubility: >0.1 mg/mL**

CR Go/No-Go decision will be made
- Based on a holistic analysis of the whole dataset
- Based on the PK/PD profile requirement

Other factors that increase risks
- Product profile requests no food effect
- Fix dose combination requirements
- Extent of controlled release required is high

Strategies Used in MR Formulations to Ensure Consistent Drug Release and Absorption of Insoluble Compounds

- **Strategies to improve API solubility/dissolution**
  - Solubilization agents
    - Surfactants:
      - Poloxamer, sodium lauryl sulfate, etc.
    - Lipids:
      - medium chain triglyceride, propylene glycol monocaprylate, etc.
  - Need to monitor if solubilization effect sustains


**Audience Survey Question**

**ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT**

Besides using solubilization agent, what are the common strategies to improve API solubility or dissolution rate?

- Convert API to a soluble salt
- Reduce API particle size to submicron range
- Use amorphous solid dispersion to improve API solubility
- All of above
- None of above
Audience Survey Question

Besides using solubilization agent, what are the common strategies to improve API solubility or dissolution rate?

• Convert API to a soluble salt
• Reduce API particle size to submicron range
• Use amorphous solid dispersion to improve API solubility
• All of above
• None of above

Strategies Used in MR Formulations to Ensure Consistent Drug Release and Absorption of Insoluble Compounds (Continued)

Salts

• Extent of solubility improvement

• Disproportionation risk
  – Low $pH_{\text{max}}$ presents a risk of converting to free base and then precipitating

• Take advantage of oversaturation
  – Some compounds can stay oversaturated for certain period of time
  – Kinetically retard the disproportionation and maintain oversaturation by adding anti-nucleation agents
Strategies on improving API Solubility/Dissolution (continued)

**Nanoparticle**
- Improve dissolution rate
- Particle size stability
  - Particle size stabilizer screening:
    - Polymers providing steric hindrance
    - Surfactant to reduce high surface energy
    - Zeta potential control

---

Strategies on improving API Solubility/Dissolution (continued)

**Amorphous solid dispersion**
- Screening polymers/lipids to stabilize the amorphous phase
- Screening antinucleation agents to further delay crystallization
- Spray-drying feasibility:
  - Solubility and stability in spray-drying solvent
  - Spry-drying process development
  - Attributes definition such as particle size, etc.
  - Amorphous solid dispersion stability
- Hot-melt extrusion feasibility:
  - Solubility of API in the polymer or lipid
  - Melting point/glass transition temperature of polymer or lipid and the use of plasticizer
  - Stability of API/exciipients at the process temperature and time
  - Process development
  - Amorphous solid dispersion stability

---

Naeem, M et al., Drug Design, Development and Therapy, 2015; 9: 3789-3799

Tran, P. H.-L. et al., Pharm Res, 2011; 28:2353-2378
Mitigation of Physical Stability

Physical Challenges
- Soluble salt converts to insoluble free form before release
- Amorphous API crystallizes before release from the dosage form
- Nanoparticle particle size increases before release

Mitigation Plans
- Understand possibility of disproportionation by determining \( pH_{\text{max}} \) and pH solubility profile
- Understand how to maintain oversaturation after pH change and deprotonation
- Use stabilizer and anti-nucleation agent for amorphous solid dispersion
- Use stabilizer to reduce surface tension and to provide steric hindrance or charge repelling in order to prevent particle size growth

MR Formulations Preferred for API with Low Solubility or Physical Stability Issues

- **Erosion matrix**
  - Swelling of matrix is limited to surface
  - Drug is not in contact with GI fluids for prolonged time
  - Lipid erosion matrix can be controlled by dissolution of the matrix or a disintegrant

- **Push-pull osmotic pump (PPOP)**
  - Pull layer allows stabilizers for maintaining physical stability of API
  - It relies on the push layer expanding to push out the API
  - Does not require API molecule to diffuse out
    - Add in solubilizing excipient to enhance solubility
    - Stabilizer for amorphous solid dispersion or nanoparticles
    - Buffer to maintain local pH

- **Ion exchange resin**
  - For an ionizable compound, an ion exchange resin can maintain an amorphous salt of the API to improve solubility
  - Salts in the gut fluid replace the API from the resin to release the API
  - Ionic strength impacts the release and crystallization before release from the dosage form
**Food Effect**

- **Solubility**
  - Improves solubility of insoluble API due to higher bile secretion
  - pH change alters solubility of ionizable drug

- **Permeability**
  - May compete with transporter and efflux
  - pH change alters Log D of ionizable drug

- **Release Mechanism**
  - Ionic strength changes may impact release rate of PPOP and ionic exchange resin

- **Formulation Integrity**
  - May increase the erosion rate and attrition on the gel layer or the expanded structure

- **Gastric Emptying**
  - May have an effect on CR formulations, frequently on the initial release rate

<table>
<thead>
<tr>
<th>Product</th>
<th>Solubility in Water</th>
<th>Type of MR</th>
<th>Food Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucotrol XL</td>
<td>Insoluble</td>
<td>PPOP</td>
<td>• No impact on lag time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 40% increase in C&lt;sub&gt;max&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• No significant impact on AUC</td>
</tr>
<tr>
<td>Dynacirc CR</td>
<td>Insoluble</td>
<td>PPOP</td>
<td>• No early dumping with food</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 25% decrease in AUC</td>
</tr>
<tr>
<td>Zyflo CR</td>
<td>Insoluble</td>
<td>Triple-layer with matrix</td>
<td>• 18% increase in C&lt;sub&gt;max&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 34% increase in AUC</td>
</tr>
</tbody>
</table>

**Audience Survey Question**

**ANSWER THE QUESTION ON BLUE SCREEN IN ONE MOMENT**

Which MR formulation design may have more challenges if solubility of API is low?

- Push-pull osmotic pump
- Erosion formulation
- Simple reservoir systems requires diffusion of API through a coated barrier
- Ion exchange resin using a soluble salt of API
- All of the above
Audience Survey Question

Which MR formulation design may have more challenges if solubility of API is low?

- Push-pull osmotic pump
- Erosion formulation
- Simple reservoir systems requires diffusion of API through a coated barrier
- Ion exchange resin using a soluble salt of API
- All of the above

Case Studies

- Case Study #1
  - Nifedipine MR formulations
    - Comparison of different formulation designs

- Case Study #2
  - MR Assessment for compounds in Discovery
    - Comparison of soluble and insoluble compounds
Case Study #1: Pharmaceutical and Biopharmaceutical Properties of Nifedipine

- Practically insoluble in water

<table>
<thead>
<tr>
<th>pH</th>
<th>°C</th>
<th>Medium</th>
<th>Solubility (mg/mL)</th>
<th>D/S Ratio Calculated (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGF pH 1.2</td>
<td>37</td>
<td>Buffer</td>
<td>0.011</td>
<td>892</td>
</tr>
<tr>
<td>pH 2.2-10</td>
<td>25</td>
<td>Buffer</td>
<td>0.005-0.006</td>
<td>1667-2000</td>
</tr>
<tr>
<td>pH 4</td>
<td>37</td>
<td>Buffer</td>
<td>0.0058</td>
<td>1724</td>
</tr>
<tr>
<td>SIF pH 6.8</td>
<td>37</td>
<td>Buffer</td>
<td>0.0111</td>
<td>937</td>
</tr>
<tr>
<td>pH 7</td>
<td>37</td>
<td>Buffer</td>
<td>0.0056-0.006</td>
<td>1786-1667</td>
</tr>
<tr>
<td>pH 9</td>
<td>37</td>
<td>Buffer</td>
<td>0.0078</td>
<td>1282</td>
</tr>
<tr>
<td>pH 13</td>
<td>37</td>
<td>Buffer</td>
<td>0.006</td>
<td>1667</td>
</tr>
</tbody>
</table>

* On the basis of the highest available single dose (10 mg) given in WHO model lists of essential medicines.

- No pKa in the range of 2 - 9
- Highly permeable without specific absorption window
- BCS Class II
- Bioavailability of IR formulations: 47% - 56%
- Elimination half-life: ~ 2 hours

Indication:
Vasospastic angina
Chronic Stable angina
Mechanism:
Calcium channel blocker

Extended release formulation is developed for:
- QD dosing regimen
- Reduce high peak/trough ratio to avoid adverse effects

Gajendran J et al., J. Pharm Sci. 2015; 104(10):3289-98,

Case Study #1: Nifedipine Extended Release Formulations

- Bi-layer osmotic pump tablet with a laser drilled orifice (Procardia XL)
  - Zero order release
  - Minimal food effect
    - Slightly alters early rate without changing AUC
  - Bioavailability is 86% of IR formulation

- Hydrophilic matrix tablet
  - Zero order release with minimal lag time
  - Significantly increased release rate with food

- Hydrophilic matrix with coating to create lag time (Nifedical XL)
  - Bioequivalent to Procardia XL

Case Study #1: Nifedipine Extended Release Formulations

- **Press-coated tablet (Adalat CC)**
  - External coat: slow release component
    - Provides zero order release for about 8 hours
  - Core: fast release component
    - Immediate release of nifedipine after the gel formation coat is eroded
  - Provide bi-phasic dissolution profile
  - Bioavailability is 84-89% of IR formulation
  - Food effect: high fat meal increases in $C_{\text{max}}$ by 60% and prolongs $T_{\text{max}}$ without changing AUC

- **Hydrophilic matrix tablet (Afeditab CR)**
  - Does not meet USP drug release test but demonstrated to be bioequivalent

- **Hydrophilic matrix tablet with pH sensitive coating (Nifedipine Extended-release tablet)**
  - Bioequivalent to Adalat CC

Case Study #2: MR Assessment for Compounds in Discovery

<table>
<thead>
<tr>
<th>Compound Attributes</th>
<th>Target Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>PK</td>
<td></td>
</tr>
<tr>
<td>Predicted human half-life</td>
<td>$\geq$ 26 hr</td>
</tr>
<tr>
<td>Good bioavailability</td>
<td>$&gt;20%$</td>
</tr>
<tr>
<td>Linear exposure dependence</td>
<td></td>
</tr>
<tr>
<td>Predicted human dose</td>
<td></td>
</tr>
<tr>
<td>Monotherapy</td>
<td>$\leq$ 50 mg/unit</td>
</tr>
<tr>
<td>Fixed-dose combination (FDC)</td>
<td>$\leq$ 50 mg/unit</td>
</tr>
<tr>
<td>Physicochemical characteristics</td>
<td></td>
</tr>
<tr>
<td>Dog colonic absorption as a solution (relative to oral)</td>
<td>$\geq$ 60%</td>
</tr>
<tr>
<td>API solubility</td>
<td>Dose/solubility $&lt;100$ mL</td>
</tr>
<tr>
<td>Stability</td>
<td>Chemically and physically stable API form</td>
</tr>
</tbody>
</table>

**CR Go/No-Go decision will be made**
- Based on a holistic analysis of the whole dataset
- Based on the PK/PD profile requirement

**Other factors that increase risks**
- Product profile requests no food effect
- FDC requirements
- Extent of controlled release required is high

MR Assessment for Compounds in Discovery

- **Compound A: Soluble**
  - Crystalline free base
  - Dose/solubility ratio: 6
  - Colonic absorption of a solution: 40%
  - BCS class I

- Feasibility formulation
  - Monolithic hydrophilic matrix tablet
  - Inactive ingredients: hypromellose, microcrystalline cellulose, lactose monohydrate, magnesium stearate

- **Compound A MR Dissolution**

- **Compound A Dog Plasma**

- **Strategy for improving solubility**
  - Prepare the following API
    - HCl salt
    - Nano API with PVP and polysorbate 80 as stabilizers
    - Amorphous solid dispersion with HPMCAS as stabilizer
  - Compared with crystalline free base matrix formulation and IR formulation

- **Compound B: practically insoluble**
  - Crystalline free base
  - Dose/solubility ratio: 1500
  - Colonic absorption of a solution: 50%
  - BCS class II
  - Feasibility focused on improving API solubility followed by hydrophilic matrix (erosion dominant) assessment

- **Nano API: average radius of 170 nm**
MR Assessment for Compounds in Discovery

Feasibility formulation: Monolithic hydrophilic matrix

![Graph showing release rate and completeness of release are enhanced by modifying solubility of API](image)

The release rate and the completeness of release are enhanced by modifying solubility of API

Summary

- Requirement for solubility is higher for MR formulation
  - To ensure consistent dissolution/diffusion rate to maintain consistent release profile
- Strategies for improving solubility of API: such as salt formation, nanoparticles, and amorphous solid dispersions, can be incorporated in MR formulation to enhance performance
  - MR formulation selection has to take into account maintaining proper physical stability of the ‘enabled API’
- MR technologies that do not rely on the diffusion rate of API, in general, have a higher success rate for insoluble APIs
  - PPOP and erosion matrix
- Ion exchange resin uses the API’s charge property to improve solubility and achieve modified release
- Food effect, GI tract disease state and transit time have to be considered to ensure consistent release profile
Final Note: Solubility Analysis of Extended-Release and All Oral Drugs

**Solubility analysis**

**Solubility value reported:** minimum solubility within pH range  
**Source:** Drug Delivery Foundation  
BCD database:  

**Solubility value reported:** aqueous solubility  
**Source:** Benet LZ, Broccatelli F, Oprea TI.  
BDDCS applied to over 900 drugs. AAPS J. 2011;13(4):519-547. Oral compounds only

Curtesy of: Pierre Daublain, Merck & Co., Inc.

Overall, no major difference between solubility for CR molecules vs that for all oral compounds, except lower incidence of solubility values <0.1 mg/mL for CR drugs

**Acknowledgments**

- Sunny Bhardwaj  
- Paul Walsh  
- Lin Chu  
- Pierre Daublain  
- Heidi Ferguson  
- Pranav Gupta  
- Kashmira Shah  
- David Harris  
- Annette Bak
References

Naeem, M et al., Drug Design, Development and Therapy (2015) 9, 3789-3799
Ovesen L et al., Gastroenterology (1986), 90:958-962

2016 Drug Design and Delivery Symposium
“Modified Release Formulations for Solubility Starved Compounds”

Slides available now! Recordings will be available to ACS members after one week
www.acs.org/acswebinars

The 2016 DDDS is co-produced with ACS Division of Medicinal Chemistry and the AAPS
2016 Drug Design and Delivery Symposium

I - Time: The Fourth Dimension in Drug Discovery
January 28  The Importance of Drug-Target Kinetics in Drug Design
Rob Codand - Epizyme, Inc.
February 25  Long-Acting Injectable Medications: Strategies and Mechanistic Considerations
Jules Remenni - Ailerons
March 31  Modified Release Formulations for Solubility Starved Compounds
Minggul Hu - Merck
April 28  The Medicinal Chemist of Tomorrow (Special Topic)

II - Beyond Traditional Small Molecules
May 19  Design of Deliverable Macrocycles
June 23  Culture Clash - Antibody Drug Conjugates
July 28  Nucleic Acids Therapeutics - Making Sense of Antisense Oligonucleotides
August 18  Special Topic (To Be Announced)

III - Pharmacology Revisited
September 29  Designing Around Toxicophores
October 27  RNA by design and phenotypic screening
November 10  Cell Penetrating Peptides to Improve Cellular Drug Uptake

Meet the Organizers
Nicholas Meanwell
BMS
John Morrison
BMS

Content Advisors
Richard Cornell
Pfizer
Dan Transom
Caron Therapeutics
Annette Squicciarini
Merck Research Laboratories
Mark Tcherevichkin
Johnson & Johnson

Co-Produced By
Division of Medicinal Chemistry
American Association of Pharmaceutical Scientists


Upcoming ACS Webinars®
www.acs.org/acswebinars

Thursday, April 7, 2016
Chemistry of Go: Innovations in Alternative Fuels
Session 4 of the 2016 Material Science Series
Jennifer Holmgren, Chief Executive Officer, LanzaTech
Mark Jones, Executive External Strategy and Communications Fellow, Dow Chemical

Thursday, April 14, 2016
Creating a Stand Out Professional Development Plan
Dorie Clark, Author and Marketing Strategy Consultant, Clark Strategic Communications, Inc.
John Mihalick, Strategic Accounts Manager, ACS Professional Advancement

Contact ACS Webinars® at acswebinars@acs.org
2016 Drug Design and Delivery Symposium
“Modified Release Formulations for Solubility Starved Compounds”

Slides available now! Recordings will be available to ACS members after one week
www.acs.org/acswebinars

The 2016 DDDS is co-produced with ACS Division of Medicinal Chemistry and the AAPS

How has ACS Webinars® benefited you?

“ACS Webinars broaden my chemical technology knowledge database. This is sometimes very useful since I work as a chemical technology consultant for my employer.”

Fan of the Week
Jack Horvath,
Senior Chemist, HydroChem LLC

Be a featured fan on an upcoming webinar! Write to us @ acswebinars@acs.org
Upcoming Events:

• Northeast Regional Discussion Group (NERDG) Annual Meeting – April 19th, Farmington CT (http://aaps-nerdg.org/)

• Contemporary Perspectives on Developing Amorphous Pharmaceuticals (Arden Conference) – April 18th to 20th, Baltimore MD (http://www.aaps.org/Arden/)

• National Biotechnology Conference (NBC) – May 16th to 18th, Boston MA (http://www.aaps.org/nationalbiotech/)

www.aaps.org

Join the ACS Division of Medicinal Chemistry Today!

For $25 ($10 for students), You Will Receive:

• A free copy of our annual medicinal chemistry review volume (over 600 pages, $160 retail price)
• Abstracts of MEDI programming at national meetings
• Access to student travel grants and fellowships

Find out more about the ACS MEDI Division! www.acsmedchem.org
Benefits of ACS Membership

**Chemical & Engineering News (C&EN)**
The preeminent weekly news source.

**NEW! Free Access to ACS Presentations on Demand®**
ACS Member only access to over 1,000 presentation recordings from recent ACS meetings and select events.

**NEW! ACS Career Navigator**
Your source for leadership development, professional education, career services, and much more.

ACS Webinars® does not endorse any products or services. The views expressed in this presentation are those of the presenter and do not necessarily reflect the views or policies of the American Chemical Society.

Contact ACS Webinars ® at acswebinars@acs.org

Upcoming ACS Webinars®
www.acs.org/acswebinars

Thursday, April 7, 2016
Chemistry of Go: Innovations in Alternative Fuels
Session 4 of the 2016 Material Science Series
Jennifer Holmgren, Chief Executive Officer, LanzaTech
Mark Jones, Executive External Strategy and Communications Fellow, Dow Chemical

Thursday, April 14, 2016
Creating a Stand Out Professional Development Plan
Dorie Clark, Author and Marketing Strategy Consultant, Clark Strategic Communications, Inc.
John Mihalick, Strategic Accounts Manager, ACS Professional Advancement

Contact ACS Webinars ® at acswebinars@acs.org