GC3 Webinar Series

Innovating with Intent: Science & Sustainability at Eastman

Wednesday, April 13, 2016

GREEN CHEMISTRY & COMMERCE COUNCIL

Business Mainstreaming Green Chemistry

What is the GC3?

- Cross-sectoral, B2B network of over 90 companies and other organizations
- Formed in 2005
- Collaboratively advances green chemistry across sectors and supply chains

90 Members, Including:

An Agenda to Mainstream Green Chemistry

Green Chemistry & Commerce Council

November 2015

Strategies to Mainstream Green Chemistry

1. *Enhance Market Dynamics* by continuing to build a comprehensive, ongoing understanding of green chemistry enablers, market drivers, and obstacles.
2. *Support Smart Policies* by designing and advocating for innovative state and federal policies that increase the supply of and demand for green chemistry solutions.
3. *Foster Collaboration* by facilitating the flow of information about green chemistry solutions and assembling partnerships to tackle priority challenges.
4. *Inform the Marketplace* by disseminating information about green chemistry business, economic, and health benefits, as well as opportunities and funding.
5. *Track Progress* by improving green chemistry metrics and periodically gathering and reporting data on progress.

Today's Speakers from Eastman Chemical Company

David Kossor

Associate Toxicologist

Carol Perkins

Industry Leader,
Industrial &
Household Care

Mark Pavlin

Sr. Technical Associate

Ground Rules

- Due to the number of participants in the webinar, all lines will be muted
- If you have a question or comment, please type it in the “Questions” box located in the control panel
- Questions will be answered at the end of the presentation

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GREEN CHEMISTRY & COMMERCE COUNCIL
Business Mainstreaming Green Chemistry

Innovating with Intent

Combining science and sustainability for a new generation of safer cleaners

April 13, 2016

Who we are

EASTMAN

- A global specialty chemical company headquartered in Kingsport, Tennessee
- Approximately 15,000 employees and 50 manufacturing sites around the globe
- Serving customers in approximately 100 countries
- A company dedicated to environmental stewardship, social responsibility, and economic growth
- 2015 ENERGY STAR® Partner of the Year Sustained Excellence
  - Fifth consecutive year
- 2016 Ethisphere's World's Most Ethical® Companies
  - Third consecutive year
- 2016 Glassdoor Employees' Choice Best Places to Work (# 11)
- 2015 revenue of $9.6 billion

Innovation with intent – a case study

Developing a new solvent for aqueous cleaners

- Why undertake this challenge?
  - Customer needs for innovative, differentiated end use products
  - Health, safety & environmental benefits and improvements
  - Changing regulatory requirements
  - Economic goals

- Why is this not done very often?
  - **Expense**
  - Time required to bring to commercial scale
  - Regulatory hurdles
  - Market risk
  - Testing and characterization requirements
  - Third party certifications (as needed)
  - Perceived innovation barrier

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Selecting the target market

Cleaning products - multiple forces driving change

Regulatory pressures

- CARB
- South Coast
- EPA, OTC
- HAPS
- Chemicals of Concern
- GHS labeling

Environmental concerns

- Ozone depletion
- Air pollution
- Water/land pollution
- Water shortages
- Climate change

Cost pressures

- Mature markets
- “Un-appreciated”
- Highly competitive
- Fragmented
- One of first “costs” to go

Performance needs

- Disease outbreaks
- Food/surface contamination
- Hospital acquired infections
- Global travel
- Antibiotic resistance

Safety concerns

- Worker protection (acute & chronic)
- Human health and safety
- Wildlife/aquatic toxicity
- Surface protection
- Public perception

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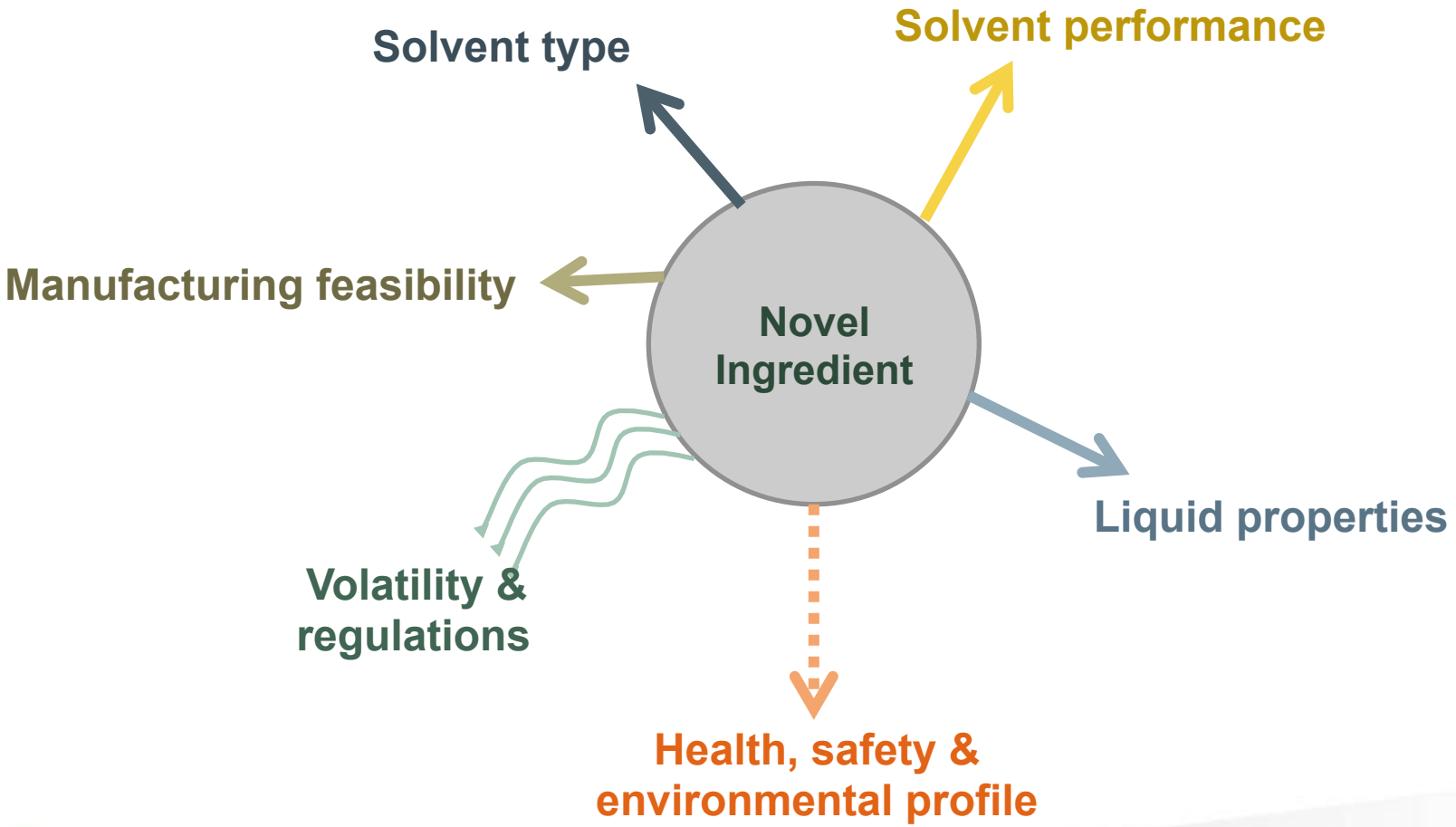
Research & Development Goals

Selection considerations

Target market requirements helped inform development



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Where to start

- Determine compound selection criteria
  - Based on intended use in target market
- Construct list of possible candidates
  - Determine what compounds should be precluded
- Manufacturing feasibility
  - Can it be produced cost effectively?
- Sub-divide the data into types for prioritization
- Calculate theoretical property values based on computer modeling

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Initial screening

- Mathematical models allow assessment of suitability of candidate compounds prior to laboratory testing

- Models used
  - EPIWEB (Estimation Programs Interface Suite™)
    - Developed by the US Environmental Protection Agency's Office of Pollution Prevention and Toxics and the Syracuse Research Corporation (SRC) to quickly screen chemicals for environmental release potential
  - HSPIP
    - ***Hansen Solubility Parameter in Practice*** developed by Steven Abbott and Charles M. Hansen in order to make easier the generation and manipulation of Hansen solubility parameters

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Narrowing the field

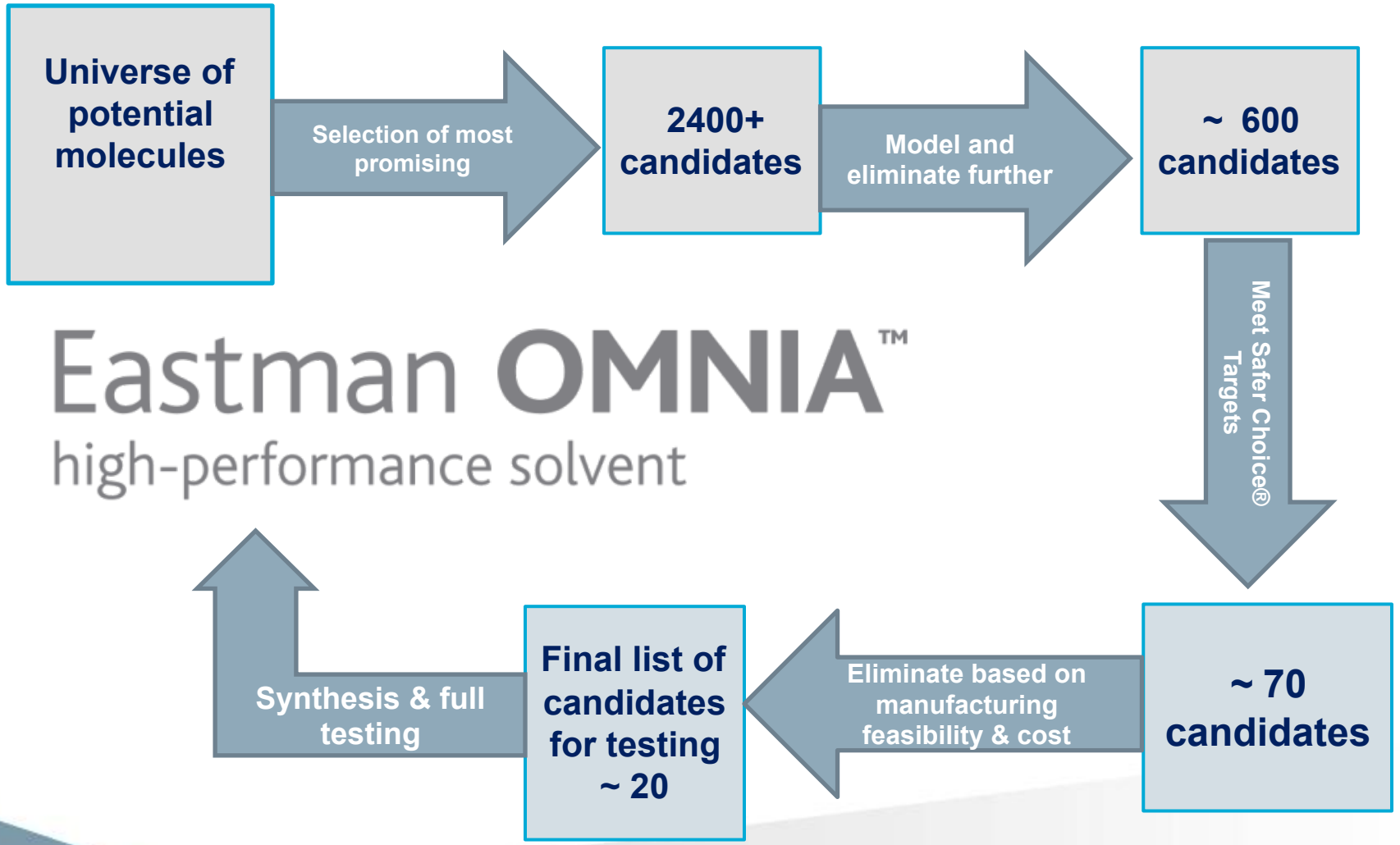
- Initial and most comprehensive list included all possible compounds of C, H, and O meeting the *a priori* criteria
  - > 2,400 compounds
- Synthesis feasibility assessment narrowed the list further
  - 596 compounds
- Final compound grouping – how does it interact with water
  - Protic (alcohol)
  - Aprotic (basic)
  - Aprotic (neutral)

Organizing and analyzing the information

- Identification of compounds
- EPIWEB model properties
  - Model physical properties – liquid properties
  - Model physical properties – volatility
  - Model physical properties – solvency
- EPIWEB model toxicity
  - Environmental safety
- Manufacturing feasibility
- HSPiP model physical properties
- Reported physical properties

Narrowing down to a manageable list

Best few candidates



Eastman OMNIA™

high-performance solvent

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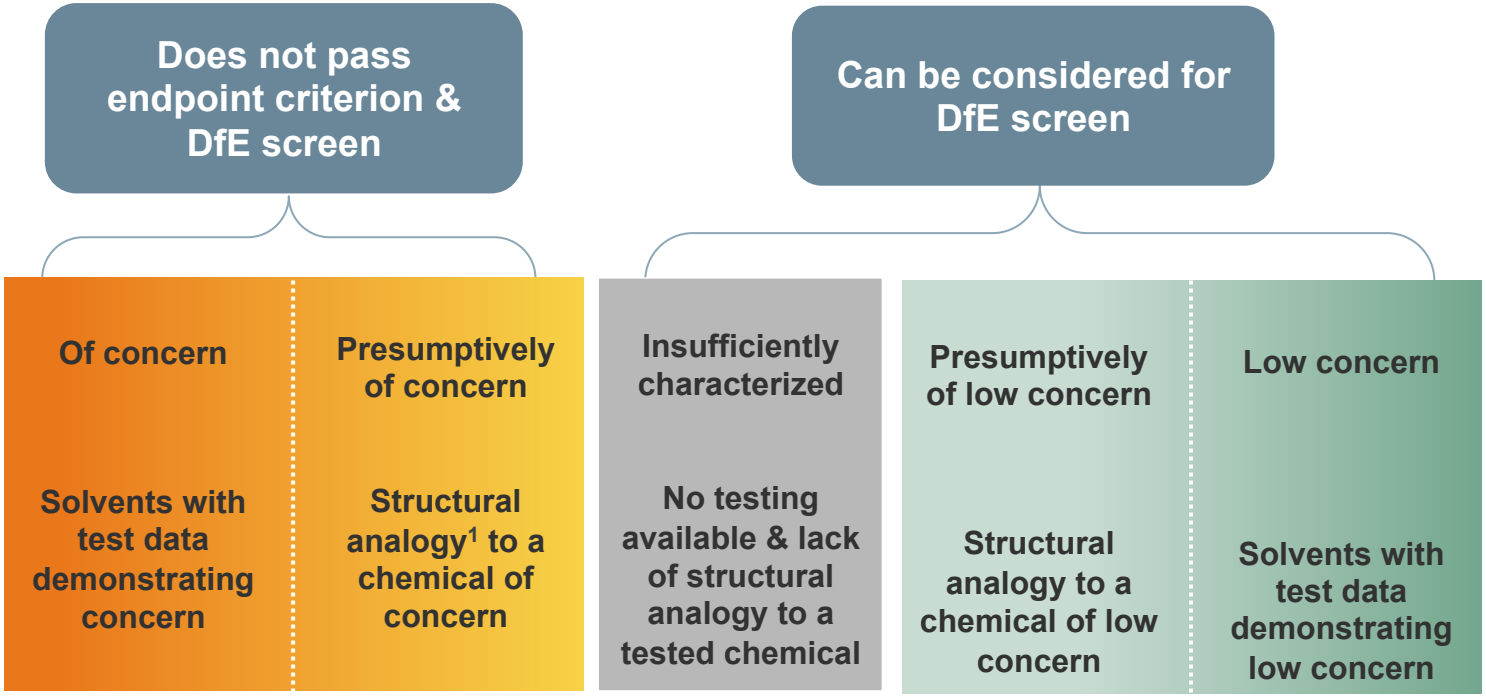
Environmental, Health & Safety Evaluation

Adherence to Design for the Environment®

(Now Safer Choice™)

- Distinguishing attributes of concern selected by DfE/Safer Choice to differentiate safer from less safe solvents
  - Carcinogenicity
  - Neurotoxicity
  - Acute mammalian toxicity
  - Reproductive and developmental toxicity
  - Repeated-dose toxicity
  - Environmental fate and toxicity



[1]Can also include metabolic or mechanistic analogy

Toxicology program

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- Program goals
  - Identify a safe and effective alternative solvent for cleaning applications
- Objectives
  - Enable product commercialization
    - Development
    - Regulatory approvals
  - Document safety endpoints to enable 3rd party certifications
  - Conserve resources using a tiered testing strategy
    - Phys/chem properties
    - In silico screening
    - In vitro testing
    - In vivo testing
- Tools
  - 12 Principles of Green Chemistry
  - Design for the Environment (DfE)/Safer Choice Solvent Screen
  - Modeling programs

Toxicology program strategy

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Tier I (computer modeling)

- EpiSuite®
  - Readily biodegradable, Bioconcentration Factor (BCF)
- Toxicity Estimation Software Tool (T.E.S.T.)
  - Mutagenicity, acute oral toxicity, reproductive toxicity

Tier II (*in vitro* testing)

- Mutagenicity (bacterial + mammalian cells)
- Endocrine disruption (ERTA)
- Biodegradation

Tier III (*in vivo* testing)

- Ecotoxicology
  - Acute toxicity (fish, plants, invertebrates)
- Acute toxicity (oral, dermal, inhalation)
- Eye/skin irritation, skin sensitization
- Repeat-dose (28-day) toxicity/developmental toxicity screen

Toxicology results - *final candidate*

Mammalian toxicology endpoints

- Acute oral LD_{50} > 5000 mg/kg in rats
- Acute dermal LD_{50} > 5000 mg/kg in rats
- Acute inhalation (mist) LC_{50} > 5 mg/L in rats
- Slight dermal irritation (no classification according to GHS)
- Moderate ocular irritation (GHS classification: Category 2)
- No dermal sensitization
- No effect on estrogen receptor signaling
- Not mutagenic in Ames assay (+/- metabolic activation)
- Not mutagenic in mammalian cells (+/- metabolic activation)
- No adverse effects in 28-day repeat dose study + developmental toxicity screen

Ecotoxicology endpoints

- Readily biodegradable
- Aquatic LC_{50} > 100 mg/L (all species tested)

Significance of findings

- Candidate solvent was shown to be exceptionally safe
  - Testing at doses up to practical limits produced no toxicity
- Eye irritation was the only finding of concern
  - Pertains to 100% solvent
  - Non-irritating at typical formulation concentrations (1-5% solvent)

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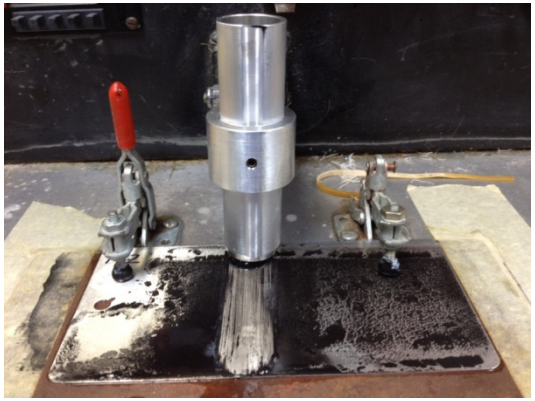
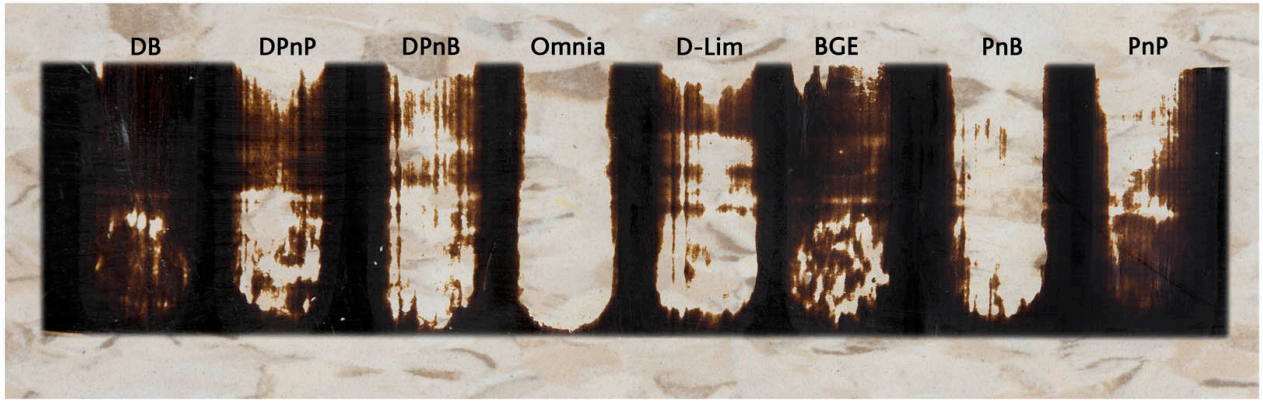
Validating Performance and Market Acceptance

Performance testing

Eastman Omnia in aqueous cleaners

- Extensive testing showed effective removal of organics at formulation levels of 0.5% and up
  - Effective in neutral pH formulations
  - Better cleaning performance compared to common solvents





DB = Diethylene glycol monobutyl ether
DPnP = Dipropylene glycol *n*-propyl ether
DPnB = Dipropylene glycol *n*-butyl ether
D-Lim = D-limonene

BGE = Ethylene glycol monobutyl ether
PnB = Propylene glycol *n*-butyl ether
PnP = Propylene glycol *n*-propyl ether

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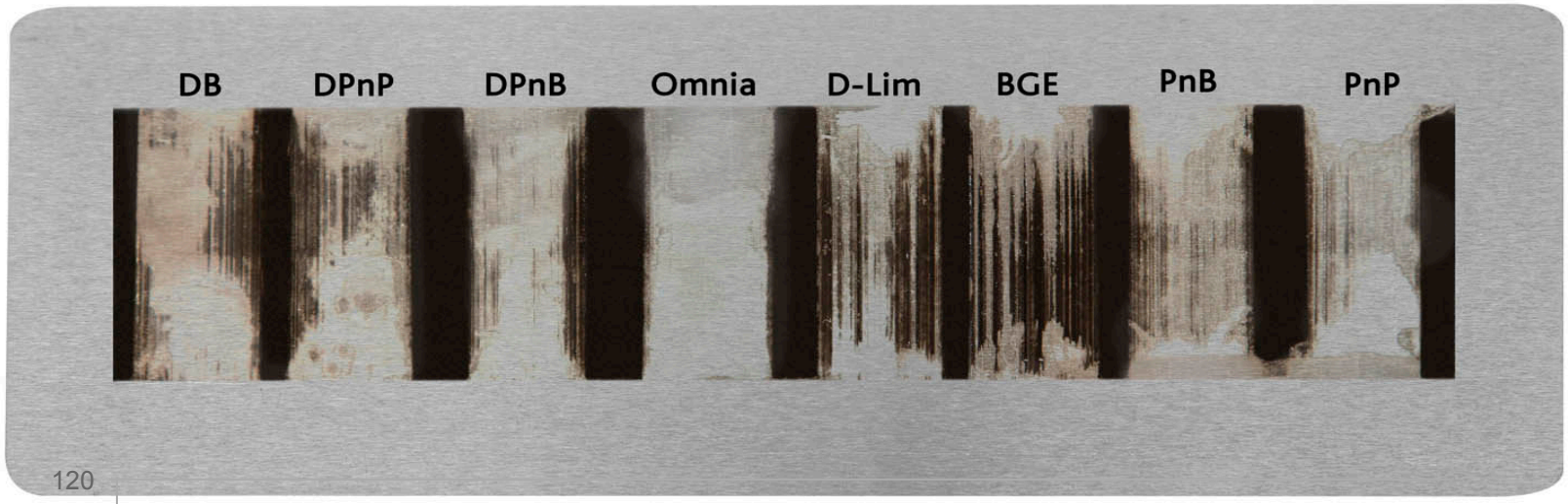
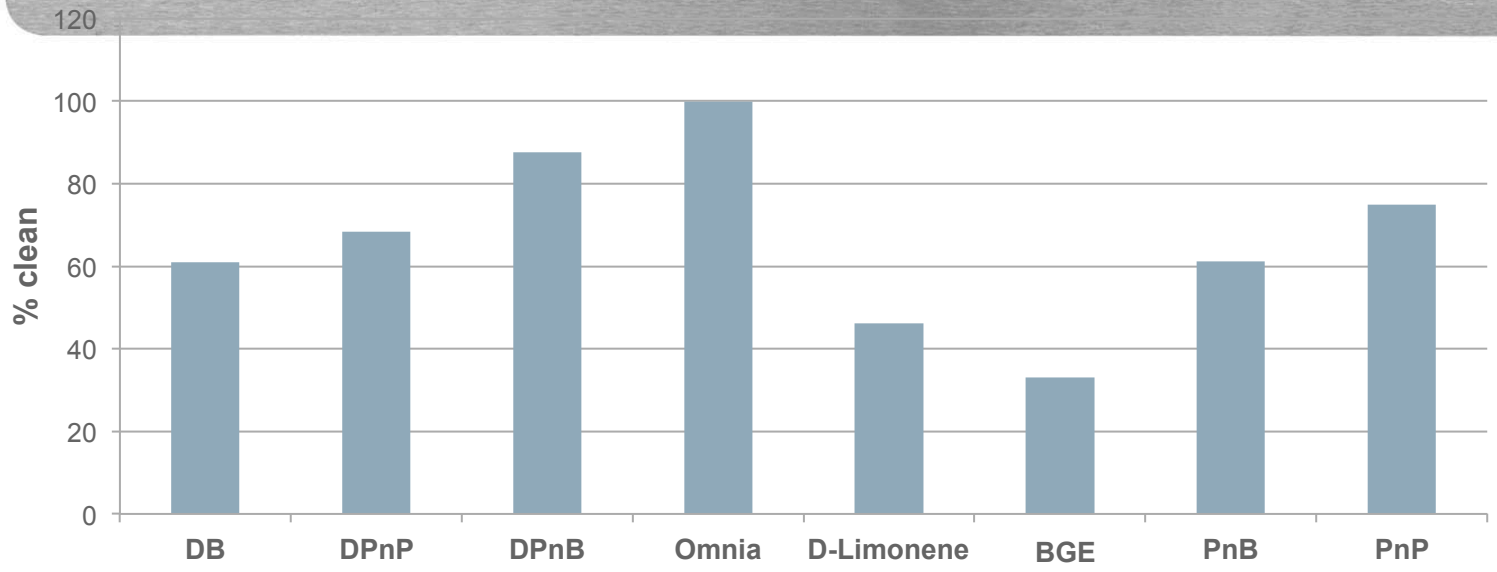
Relative cleaning performance of Omnia

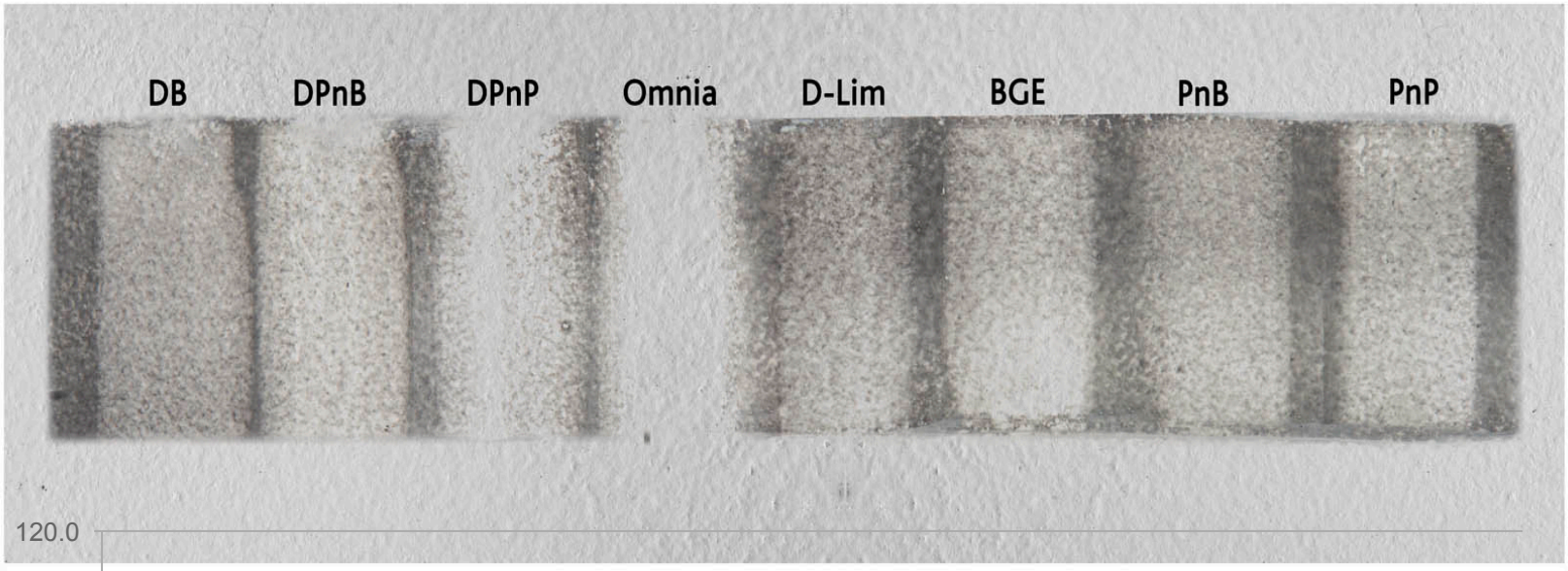
Greasy soil on an aluminum Q-panel

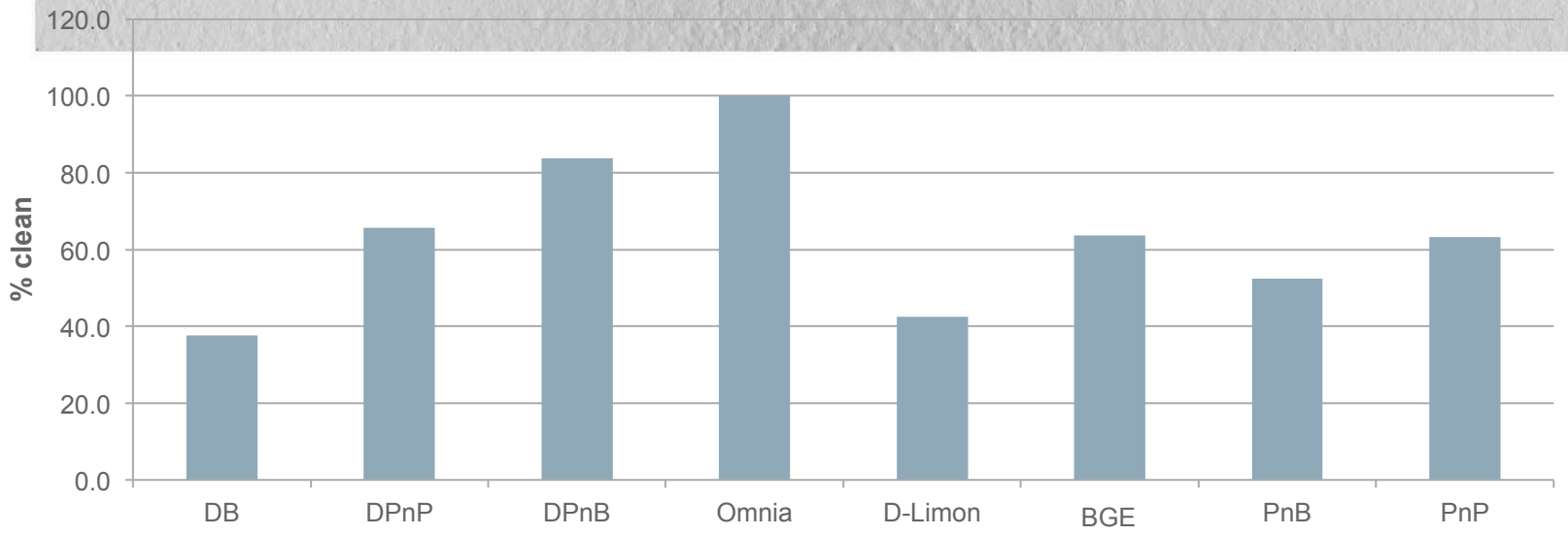




Relative cleaning performance of Omnia

Soap scum on painted wall board





Eastman Omnia high performance solvent

Meeting the cleaning product needs of tomorrow

Safe

- Acute oral LD_{50} > 5000 mg/kg
- Aquatic LC_{50} > 100 mg/L
- Non-mutagenic
- No effect on estrogen receptor signaling

Effective

- Removes wide spectrum of soils - grease, tar, soap scum, inks
- "Green" that actually cleans
- Easily formulated as RTU or concentrate

Environmentally responsible

- Readily biodegradable
- Effective in neutral pH formulations
- Listed on CleanGredient™ with no restrictions
- Listed on EPA's Safer Choice SCIL with full green circle

Regulatory compliance

- REACH compliant; listed on EPA's TSCA; Canadian DSL
- Meets CARB and U.S. EPA criteria for classification as an LVP-VOC in consumer products
- Meets EPA criteria for direct release

Economical

- More efficient at removing soils than comparable solvents
- Effective at low % use levels

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Market validation

- Selected “alpha” partner in the industrial & institution market
  - Nyco Products, Chicago IL
- Helped with validation of performance prior to commercial launch
- Introduced three new cleaners concurrently with Eastman’s market launch of Omnia

“The OM1 cleaners Powered by Omnia™ from Eastman are by far the best cleaners we’ve ever produced.” - Bob Stahurski, President, Nyco Products

Commercial launch

Omnia high performance solvent (2013)

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- ✓ Customers told us they wanted safer ingredients to use in formulations
- ✓ Performance validated
- ✓ Solvent safety validated
- ✓ CleanGredients approved – no restrictions
- ✓ EPA Safer Choice approved – full green circle
- ✓ EPA-permissible for direct environmental release
- ✓ Momentum building for chemical companies to innovate and provide safer options
- ✓ Met criteria for low vapor pressure (LVP) exemption under CARB and EPA guidelines
- ✓ PMN filed, TSCA approved
- ✓ DSL approved, REACH pre-registered

……But customers weren't lining up to purchasing Omnia

Challenges we faced

- "What we have is safe enough"
  - If what they are using isn't banned or restricted, then change is difficult
- Industry cleaning tests are subjective at best
  - "Our customers are happy with the products we have"
  - "What we have is good enough"
- Omnia is a ***new*** material
  - Not a drop in replacement

- "We just reformulated to meet CARB rules (2012)"
  - It's too much work to reformulate again, even if it will be better and safer
- "You need high (or low) pH to clean"
  - Staying with the status quo is easier
- No "pull" from distributors, end users, and/or retailers

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Mitigating objections

- Educational outreach
  - Value chain discussions
  - Industry presentations
  - Trade shows
  - Media interviews
  - Articles in relevant publications
- Developed extensive formulation guidelines and starting point formulations
- Personally visited virtually every cleaning product manufacturer in the US and Canada – over and over

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Lessons learned

- The “better mousetrap” argument stands, even with safer, more effective chemicals
- The market must be willing to support manufacturers who “step up” and invest in safer chemical innovations
- Regulations (government and retail) play a critical role in adoption of safer ingredients
  - Unfortunately, most companies won’t change without them
- Change is harder than you hope and slower than you expect
  - “Green Chemistry” is still not mainstream

Summary

- *Inventing* a new solvent is the easiest part
- *Innovating* to provide a proven new solvent that meets the needs of the market AND will get adopted is NOT easy
  - Safety
  - Environmental
  - Regulatory
  - Performance
  - Economics
  - Inertia
- Significant *investment* in market insight, technical resources, testing, and characterization is required to bring a product to full commercialization
- All parts of the value chain – from manufacturers to retailers – must support and embrace these efforts for real change to happen

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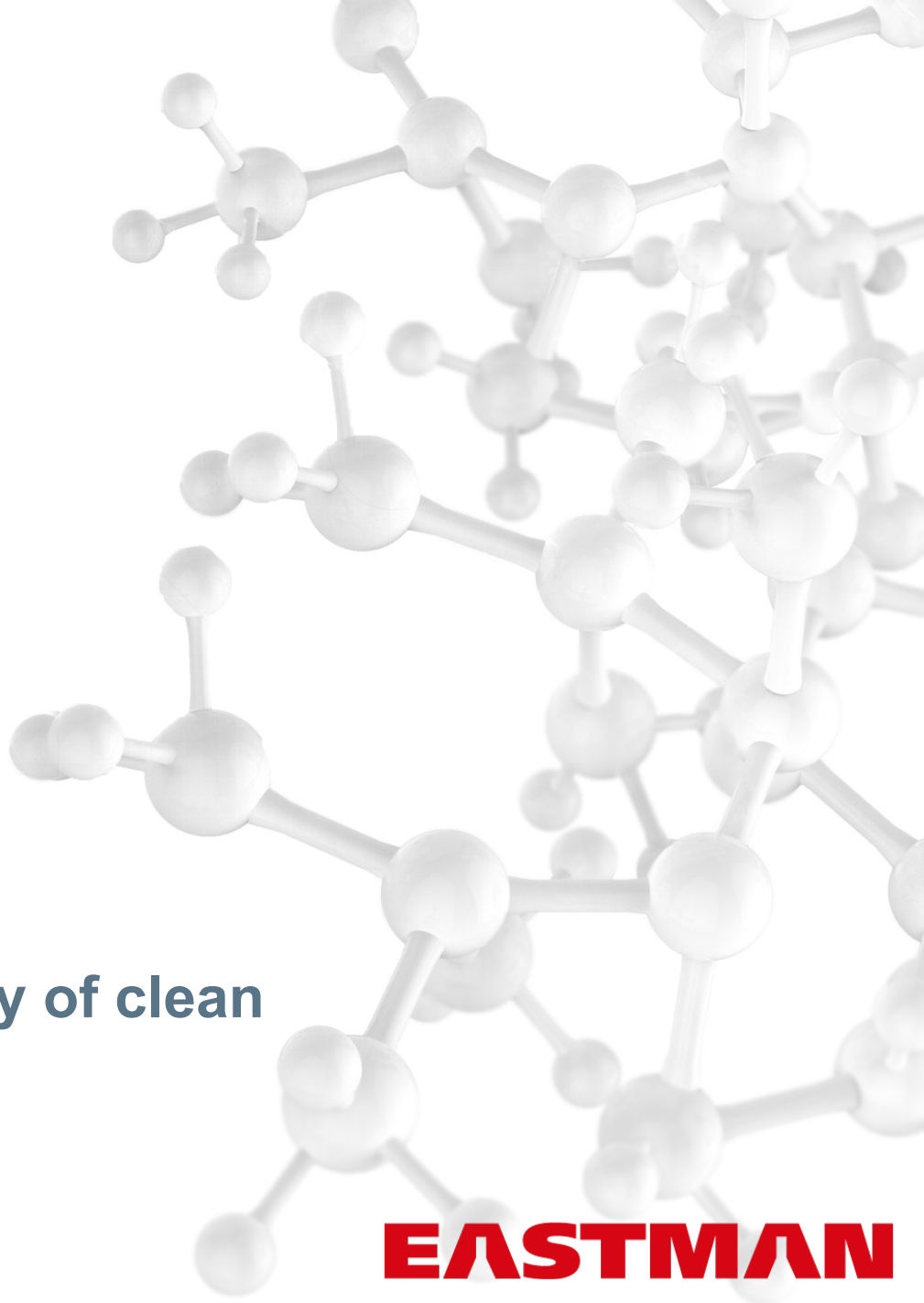
Thank you!

Eastman Omnia™
high-performance solvent

Changing the chemistry of clean



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Upcoming Events

WEBINAR

VAUDE – Our Journey to be the Most Sustainable Outdoor Brand in Europe

Tuesday, April 26, 2016 at 12:00 PM ET

11th Annual GC3 Innovators Roundtable

May 24-26, 2016 in Burlington, VT
Hosted by Seventh Generation

Thanks for joining us!

For more information about the GC3:
www.greenchemistryandcommerce.org

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