Good morning!

Today I have the privilege of telling you about **ecomate**, an environmentally benign Foam Blowing Agent.

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As energy prices soar, we have an increasing urgency to conserve our natural resources. This includes the energy used to heat our homes and workplaces. This raises our attention to the need for efficient insulation.

Efficient Insulation will save energy and resources by reducing heat losses, whether convective, conductive, or radiant Losses; AND it will reduce drafts.

Of course it will also protect the environment by reducing the amount of CO2 and other pollutants generated from the burning of fossil fuels.

The efficiency of insulation depends on the resident gases trapped in the insulation.

Fiberglass and cellulose depend on trapped DRY air, but as the moisture content of the air increases the insulative value drops markedly . . . and they are prone to DRAFT FAILURE.

Insulating foams as well depend on the properties of the gases trapped in them, which we call FOAM BLOWING AGENTS.

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We will be talking about one particular type of foam: PU Foam based on isocyanate chemistry. Many of you may be familiar with this chemistry since it is currently a $4 Billion industry, but if not, let's quickly review:

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Of course there are a number of other ingredients used in a foam formulation:

- Surfactant to control cell formation
- Catalysts to control speed of reaction,
- Misc Adds to modify properties and give a degree of fire resistance.

- Finally, the BLOWING AGENT – to control density and give good thermal properties.

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Blowing agents for PU foams are PHYSICAL BA's – that is they blow foams because of their unique physical properties, not because of a chemical reaction to form a gas. Here we see the requirements for blowing PU foams.

Interestingly, as we add ENVIRONMENTALLY BENIGN, we begin to loose NON FLAMMABLE.

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Now for a quick history of the BAs used:

- **Water** is in fact a Chemical BA. It reacts with isocyanate to form CO2 and polyurea. It is still widely used today either alone or as a co-blowing agent, to cut the high cost of current agents. It produces foams with poor thermal properties.
- **CFC**s were adopted in the 50-60's as the BA of choice because they were non-flammable, had all the requirements previously mentioned, and produced foams with good insulative properties.
- They were replaced with **HCFC**s in the late 80's because of ozone depletion concerns. Because they were slightly different in certain properties, such as solubility, it took a few years before people began to embrace them.
- In the mid 90s, **HFC**s were introduced to better address GW concerns.

With each change the molecules became more complex, harder to manufacture and often containing more F, and thus more expensive.

And with each change, the industry adapted with formulations specifically tuned to the new BA – usually increasing the amount of water used to mollify the higher cost.

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Now let's learn some environmental jargon!

- **ODP** – Ozone Depletion Potential, the relative amt of ozone destroyed by ClO formed from breakdown of chlorine containing substances.
- **GWP** – Global Warming Potential, the equivalent amount of warming produced by these aerosols relative to CO2
- **VOC** – Volatile Organic Cmpd – a smog producer!

CFCs were deemed completely safe until initial environmental OD assessments were made.
HCFCs improved on ODP, but were plagued with moderate GWPs.
HFCs were ZERO ODP, but still had GWP issues.
No Fluorochemical was a smog producer.

Pentanes were much lower cost, and clean except for SMOG production. They have relatively POOR solubility in form formulations.

MF is an attractive long term environmental option with ZERO ODP, negligible GWP, and is VOC exempt by the US EPA.

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So what is Methyl Formate? It is the methyl ester of formic acid, which has very good solubility for all urethane raw materials. It is a clear, colorless flammable liquid with a slight ethereal odor. We will go over all the properties in more detail later. Suffice to say for now that it has a boiling point of nearly 32C [89F], and a MW of 60. And the only product on the market to be ZERO ODP, GWP & VOC EXEMPT.

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The thermal efficiency of MF is very close to the lead HFCs in today's market. Note that CFC-11 had excellent thermal properties, and that pentane and CO2 are quite poor.

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In fact the best optimal thermal conductivities in foams have fallen off with conversion changes from CFC to HCFC to HFCs. To obtain equal insulation efficiencies, one must use ~40% thicker insulation today than when using CFC11

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So why is MF a Best Choice for Foam BA?

- First it is NOT petrochemical feedstock dependant. It is made from the carbonilation of methanol, has a more stabile price than HCs, and is 3-4X less expensive than FCs.

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Besides any economic advantage, It is a most efficient BA. Let me elucidate:

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In side-by-side trials MF has produced equivalent insulation to 134a, 245fa, and 22 when trialed in drink dispensers, vendor cabinets, and display cases; and has since been commercialized in same.

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If all the Halogenated BAs are eventually banned, then there will be ONLY flammable BAs to choose from. Currently work is being done with HFEs, but these will be equally as expensive, have not yet cleared TOX TESTING, & may develop stability issues.

Worse case scenario leaves us with MF and the pentanes.

- MF has a lower MW so less is required for an equivalent density
- A lower BP means less densification on a cold substrate – or less heat needed to efficiently mold.
- Generally the lower the gas lambda, the more efficient the insulation.
- And the better the solubility, the easier with which to formulate. For flammable materials, the better solubility, the less vapor in the head space, and the higher the compounded flash point.

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MF is the least flammable of the lead candidates because:

- Its neat Flash Pt is higher
- Its Lower Flammable Limit is higher – 50,000 ppm before a sufficient amount is present to burn. This is 3 – 5X higher than HCs.
- The heat of combustion is lower, so even if it does ignite it will only burn lightly, because it is partially oxygenated already. In fact, the HOC is lower than MeOH [sterno].
- Because of its lower HOC, it does not add to the fire load of a formulation. Therefore, Formulations using it do not require extra FRA to meet fire codes. Pentane formulations gennerally require an increase of 15-30% extra FRA.

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It is also environmentally BENIGN -

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For it has zero ODP, and negligible GWP

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Let's examine Global Warming a bit further. Here we have a list of blowing agents still in use around the world. MF has the lowest MW.

Since a mole of one gas fills the same volume as a mole of another gas, we can see that it takes **1.5 – 2.5X** more of these other BAs to BLOW the same density foam.

If we multiply the Hundred Year GWP by the weight ratio for equivalent density, we arrive at a relative GWP **[or lbs of CO2 equivalents / lb of MF used.]** You can see that we can save approximately ONE METRIC TON of CO2 equivalents for every lb of MF conversion.

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Now let us consider SMOG or Photochemical Reactivity….compounds are judged according to their **Maximum Incremental Reactivity** [gram O_3/gram VOC emitted]. While the Fluorochemicals are not considered VOCs; if they are legislated away, we will be left with only a small handful of solvents that will Blow foams, yet NOT DISSOLVE them, and not contribute to smog.

For instance, pentane CANNOT be used in certain Non-Containment areas today. Methyl Acetate, and Acetone have too high a solvency to be used in rigid foams, while ETHANE lacks solvency.

MF has lower MIR than most exempt compounds
and is VOC exempt by the US EPA

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In addition to the other previous points made, MF has lower emissions during processing because of its **high solubility.**

MF requires fewer molar equivalents than other blowing agents to achieve equivalent density, because MF tends to be **better solubilized** in the polyol mixture. Less blow-off than with other molecules. We have seen this thru 8 years of working experience.

And MF will have low environmental impact at the end of product life.

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For instance, the American Home Appliance Manufacturers recently ran a Refrigerator Recycle Study [which you can reference in the J Air and Waste Management]

The study consisted of 8 refrigerators, 2 each from four mfgrs, which were 15-20 years old and blown with CFC11 or HCFC 141b.

They found that virtually all of the BA was still in the Foam.

They found that 25% of that BA was lost during shredding of the units, which meant that 75% was put into the landfill.

They found, in the same study, that CFCs and HCFCs degrade in the land fill.

But that HFCs do NOT degrade in the landfill. Thus we will have a huge legacy to leave to our children and grandchildren.

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Thus the State of California has passed the **Global Warming Solutions Act of 2006** to manage Foam Recovery and Destruction.

It covers Refrigerators, Freezers, and certain insulated buildings [such as walk-in-coolers].

It mandates the recovery and destruction of these high GWP Green House Gas blown foams at the end of their lifetime.

We expect other states to follow, lest we have a huge legacy of Fluorochemicals leaching into the atmosphere. But what about the rest of the world? What legacy are they leaving our grandchildren?

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So in conclusion: "Why is MF a Best choice to replace Fluorochemicals?'
First of all it is:

- Not Petrochemical Dependant
- A most efficient BA – not only in thermal efficiency, but also economically!
- It is the least flammable of all the non-fluorochemicals
- It is truly benign to the atmosphere, being the only candidate that is zero ODP, GWP, and Voc exempt.
- Its use permits the savings of 1 MT of CO2 eqs for every lb of ecomate used.
- It has been proven to be commercially viable for the last 8 years

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MF is one of the many ways we can protect our environment, save precious natural resources, and not leave an ugly legacy behind. Thank you