

Challenges & Opportunities

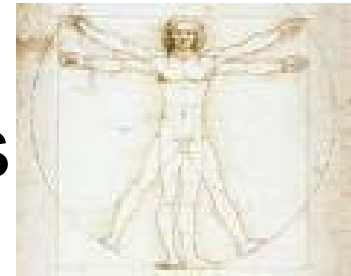
The Road Ahead ...



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Innovation Areas

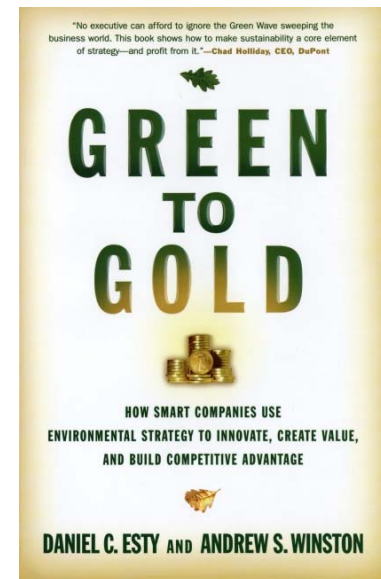
- R&D in Adhesive Sciences (Soy, Tannins, MDI, Scavengers)
- Advanced Analytical Techniques
- ASTM Standards
- Manufacturing Process Changes
- RFID Smart-Panels



There are many other areas of innovation in response to changes in the green era.

Consumer Perspective

- Paradigm Shift in Market
- Consumers expect the green attributes on commodity products
- Market may not reward producer a premium price for green property.
- Regulators set the bar – expect innovation by industry.
- Small government model (drive market to change and implement)



Daniel C. Esty and Andrew S. Winston; Yale University 2006

Non-Formaldehyde Adhesives

- Soy-based adhesives – early adopters stage
- Isocyanates (MDI) – availability limited
- Tannins – supply and process control
- PVA – limits physical properties, heat durability of glue-bond is inferior.
- Wood-welding – Immature Technology
- Biodegradable GlyTar Polymer (new kid on the block)

Biodegradable Polymer - GlyTar

- Glycerin (Biodiesel Waste)
- Tartaric Acid (Brewery Waste)
- Polymerization product maybe useful as furniture glue, particleboard glue, ...
- Decomposes into original compounds (water soluble)



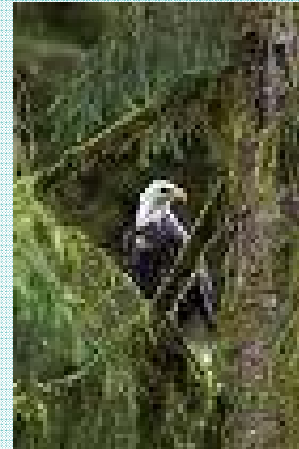
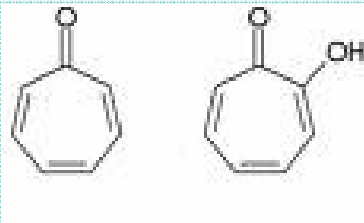
Source: <http://classes/engr/oregonstate.edu/che/winter2007/che415/group10/>
Patent Pending - O'Connor, Paris, Glarnorg, Warner-Tuhy 2007.

VOC Regulation on the Horizon?

- Volatile Organic Compounds occur naturally in wood (resins, terpenes, isoprene)
- pleasant scent and odor of forest products
- Pharmaceutical applications of forest products.

Example:

Alaska Yellow Cedar contains nootkatone, a tropolone, with similar efficacy as DEET. Potent insecticide recognized early by native Americans; also an HIV1-Inhibitor



Manter, D.K., Karchesy, J.J.; Kelsey, R.G. 2006. Forest Pathology 36: 297-308.



ASTM Test Methods

- Desiccator Test (ASTM D 5582)
passive, small-scale, easy
- Small Chamber Test (ASTM D 6007)
DMC, small-scale, dynamic
moderate difficulty level
- Large Chamber Test (ASTM E 1333)
active, dynamic, complex, large-scale,
accurate



EN-120	Perforator Method
EN-717	Gas Analysis Chamber
JAS1460	Desiccator (Japan)
JIS A1901	Small Chamber (Japan)

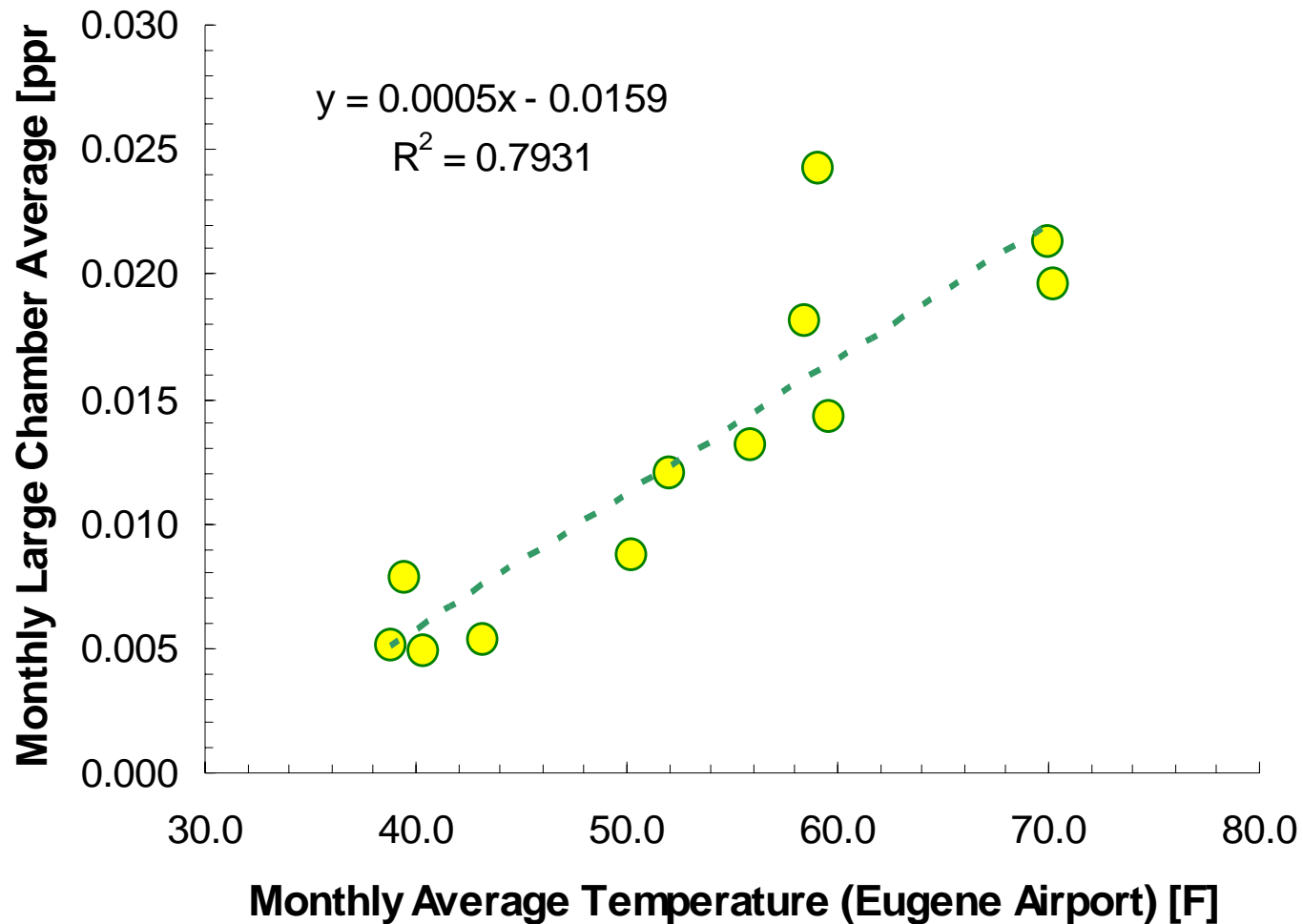
Large Chamber ASTM E1333

- 25 deg. C
- 50% RH
- 60 min sampling time
7d equilibration time
- 24 hr in chamber
- Air Exchange (Q/V) = 0.5 / hr
- Loading Ratio: (A/V) = 0.95



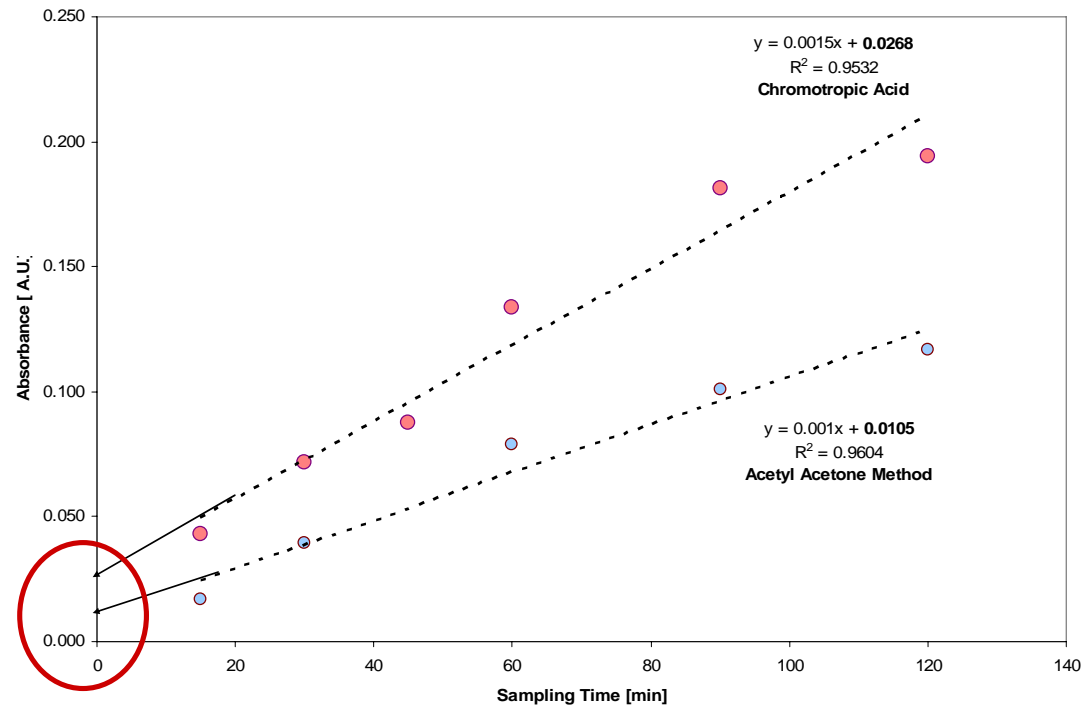
Results are reported in ppm Formaldehyde released at equilibrium condition.

Chamber Background



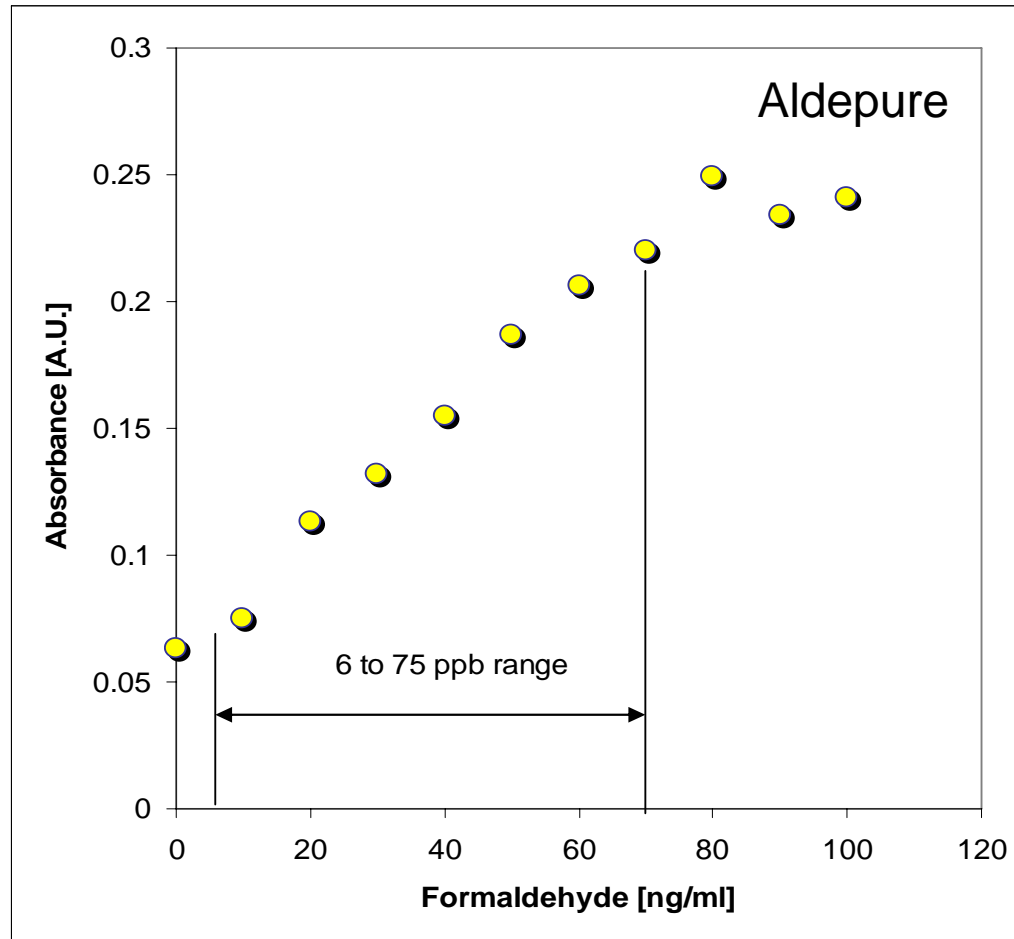
Interferent compounds (ozone, NO_x) more abundant in warm air.

ASTM standards



- ASTM standards use chromotropic acid as indicator (large chamber E1333, small chamber D6007, and desiccator)
- European and Japanese have implemented Acetyl-Acetone method (EN717-1, JIS1460 ...)
- DNPH acceptable,

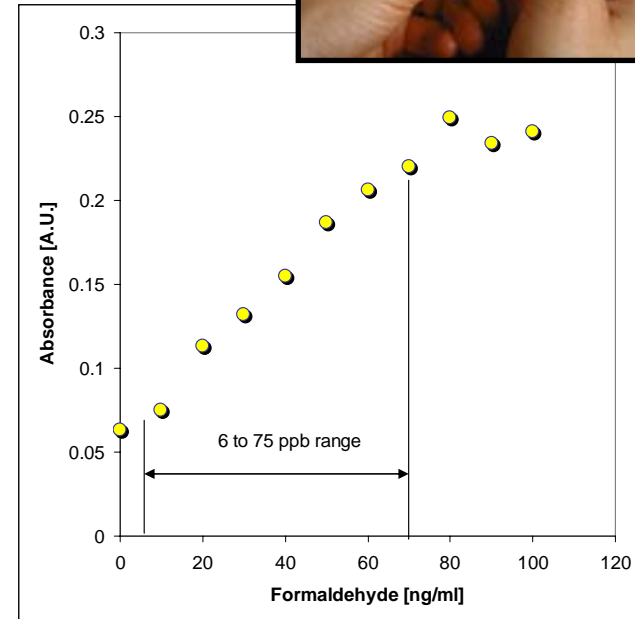
New Indicator Reagent



Sensitivity increase 10X, but limited to 0.075 ppb linearity for Beer's law to apply.

Field Test Methods

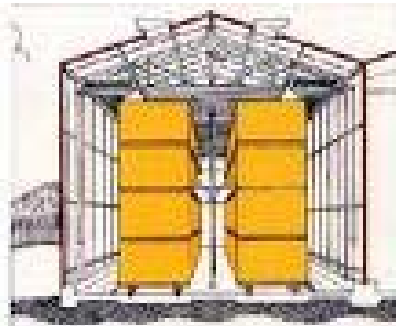
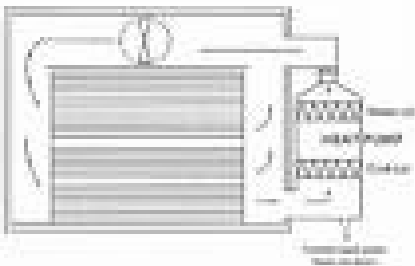
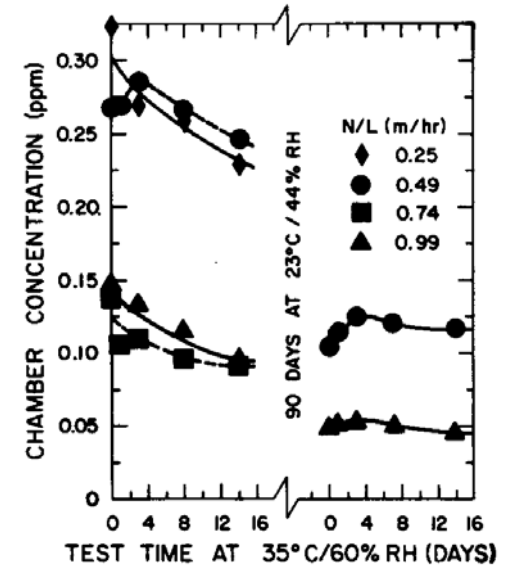
- Nanomolar Sensitivity
nmol $\sim 3 \times 10^{-9}$ g formaldehyde
- New colorimetric reagents available
- “Sensors on a chip”
microchemical IC’s



Field methods are only suitable where they can be reasonably calibrated to large chamber results – useful for screening only.

Process Opportunities

- Process Modifications (Post/Pre)
- Degasification of Panels?
- Finite amount of free Formaldehyde
- High release rate at elevated temperature, scrubbing possible.



Myers, G., Formaldehyde emission from particleboard
FOREST PRODUCTS JOURNAL Vol. 33, No. 5, 1983

Urban Wood Waste

- Urban Wood Waste Recycling
- High variability in fiber source material



- Potential emissions despite non-formaldehyde adhesives
- Uncertainty could limit recycling programs.

Competitive Threats ...

- Product substitution from non-wood based materials such as glass, plastics, gypsum and metals.
- Environmental impact of substitution products likely higher with respect to energy and atmospheric carbon balance.



TOL takes its Toll



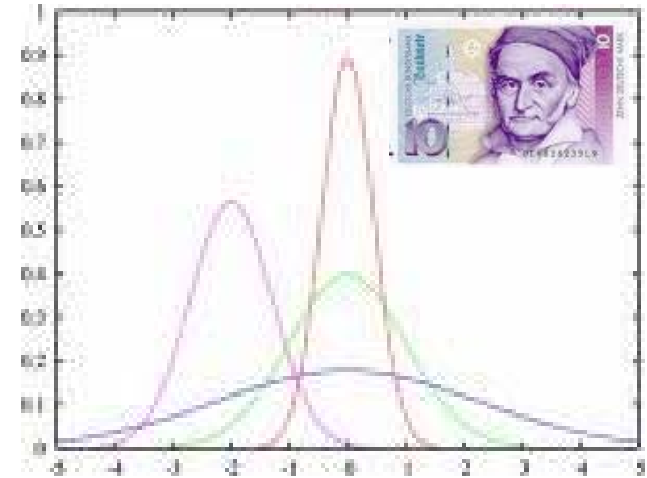
- Target Operating Limit (TOL)
- *...incorporates an operational compliance margin to account for process variation to keep the product's emissions from exceeding the applicable standard...*
- *"... When the emission are high, I turn on the scavenger spigot ..." – "... Turn the knob, Bob..."*

It is imperative to have most accurate analytical method in order to reduce variance. Third Party Certifier must understand and distinguish raw material fluctuations from poor laboratory and QA practices.

Even if the product fully complies, inferior internal and external QA could cost A medium-sized plant more than \$50,000 per month in additional glue cost.

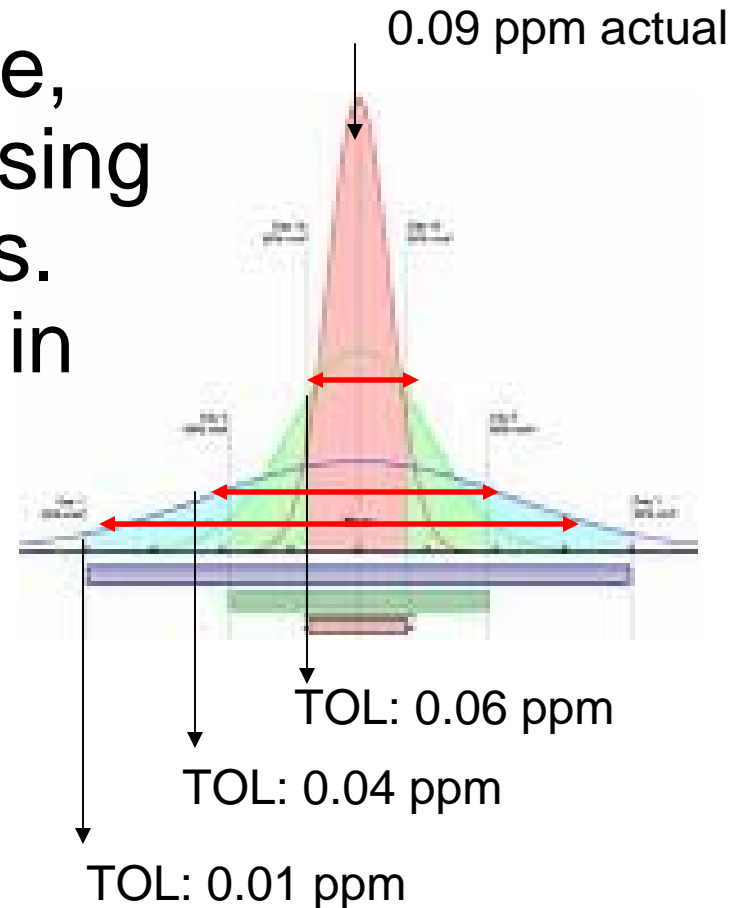
MSR Lumber Analogy

- Machine Stress Rated Lumber is a highly value-added product and **yield** depends on the accuracy of stress-grading equipment.
- Poor equipment = less profits



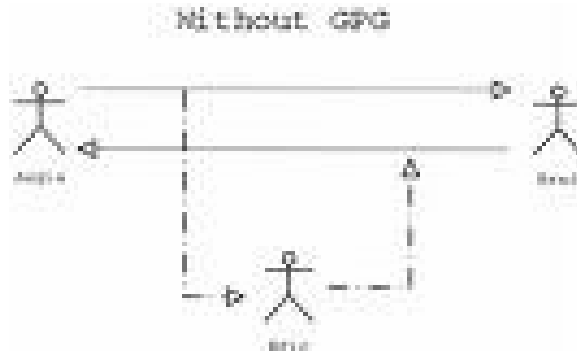
Analytical Uncertainty

- Analyze the same sample, multiple times ($N > 25$) using three different techniques. Determine the **Variance** in Result Population.
- Calculate **Separation Factor** to determine TOL.



Trusted Sample Protocols

- Questions about the capability and integrity of laboratories have been raised.

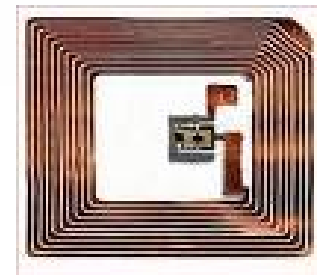
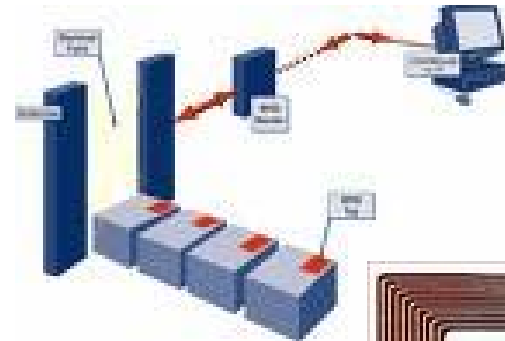


Use a trusted intermediary between laboratory and producer. Eliminate the direct transfer of samples. Add control samples to test laboratory's accuracy.

Importers must be able to rely on laboratory analyses.

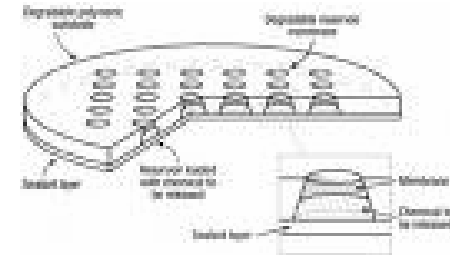
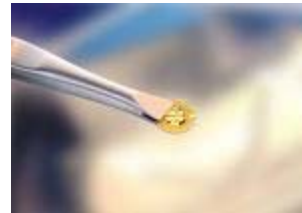
RFID and Smart Tags

- Radio Frequency ID
- Easy panel identification and COC traceability
- Cost about \$0.30 per chip
- Not useful when panels are cut to final size (transfer RFID data to a new chip)
- “Cradle to grave” IT system



Smart Tags – HCHO Dosimetry

- chemical sensors
'on-chip' design



- Passive dosimetry of formaldehyde well known (Badges)
- Correlate to emissions standards
- Embedded in product – remote readout via RFID possible

Summary

Innovation Needs in Aftermath of Regulation:

- Improving Existing Resins
- Development of new adhesives
- Harmonization of Standards
- Product Information Technology
- Manufacturing Process Improvements
- Team approach from forest to consumer

