



Roof Testing Facility at ORNL
Building Technologies Research and
Integration Center

PM: Andre Desjarlais

PI: Meng-Dawn Cheng, Ph.D.

David Graham, Ph.D.

Sue Carroll

Steve Allman

Dawn Klingeman

Susan Pfiffner, Ph.D. (FY12)

Karen Cheng (FY12)

Partner: Joe Rokowski (Dow)

New Cool Roof Coatings and
Affordable Cool Color Asphalt
Shingles

Meng-Dawn Cheng

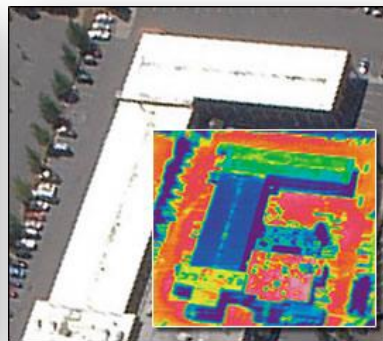
Oak Ridge National Laboratory
chengmd@ornl.gov; 865-241-5918

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- Building accounted for 41% of the US energy consumption in 2010 greater than either transportation (28%) or industry (31%).
- Building is responsible for 40% CO₂ emission in the US.
- Emerging Technologies (ET) is one of the three-pronged strategies of BTO to meet its goal in energy saving, energy efficiency improvement, and reduction of greenhouse gas emissions.
- Cool roof technology for building envelop is supported by BTO missions under its ET program aiming for high-impact energy saving and reduction of greenhouse gas emissions.



Industry Building



Thermal Imaging

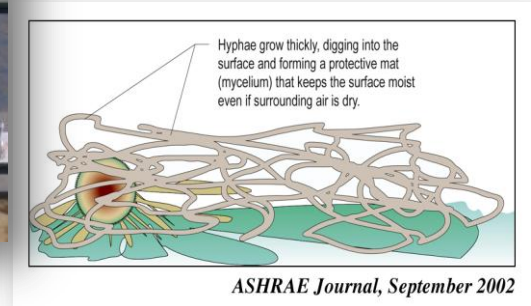
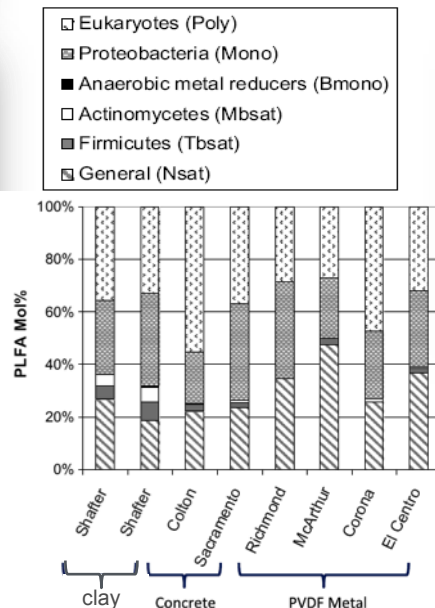
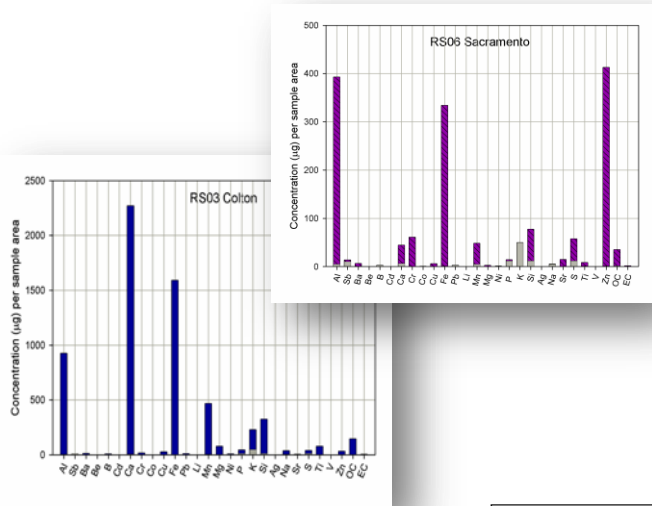


Residential Building

- **Problem Statement:** To meet product standards (EPA EnergyStar and International Energy Conservation Code) require cool roofing products must undergo an evaluation of their surface properties (solar reflectance and thermal emittance) after 3 years of exposure to natural environments. Microbial degradation of coating performance is prevalent throughout the US and world.
- **Impact of Project:** The results will enable US-based roofing and coating industry to accelerate performance testing of their products from 3 years to a month or so, and enhance the market penetration and economic competitiveness.
- **Project Focus:** Significantly enhance the next generation of polymers for roof coatings and asphalt shingles to reduce energy consumption of new and existing roofs. The BTO's goal impact for this technology is estimated at \$3.71/MMBtu.

Key Issue – Microbial Contamination

- Analysis of elemental and carbon profiles of roof samples on coupons collected at 1.6 (in 2006) and 4 (@2008) years of elapsed time.
- Comparison of the 2 time points suggests Si and OC were the two major species accumulated over time
- PLFA suggests OC is associated with biomass, possibly mixed microbial communities

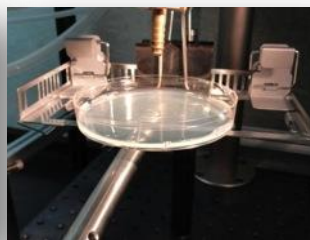
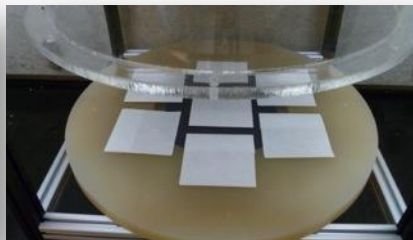


- Cheng, Pfiﬀner, Miller, and Berdahl (2011) *Building and Environment*, 46: 999-1010
- Cheng, Miller, New, and Berdahl (2012) *Construction and Building Materials*, 26: 516-526

- New Cool Roof Coating – Microbial
 - Identify microbial communities on roof samples
 - Establish an aging procedure using microbial communities
 - To allow products to be tested and moved to market more quickly than current testing methods which require exposure of roof to ambient conditions for three (3) years.
- Cool Color Asphalt Shingles
 - Determine first estimate of cost limitations for coating shingles



- New Cool Roof Coating – Microbial
 - Develop a sampling protocol for taking environmental microbial samples, *Seek industrial acceptance*
 - Establish geographical distribution of microbial communities, *Map to guide the design of microbial testing procedure*
 - Devise a microbial cocktail for accelerated testing
 - Design a practical incubation system
 - Establish a quantitative relationship between physical parameters like surface reflectance, temperature, relative humidity (or moisture), etc. and microbial activities
- Cool Color Asphalt Shingles
 - To develop a cost effective retrofit coating for shingles

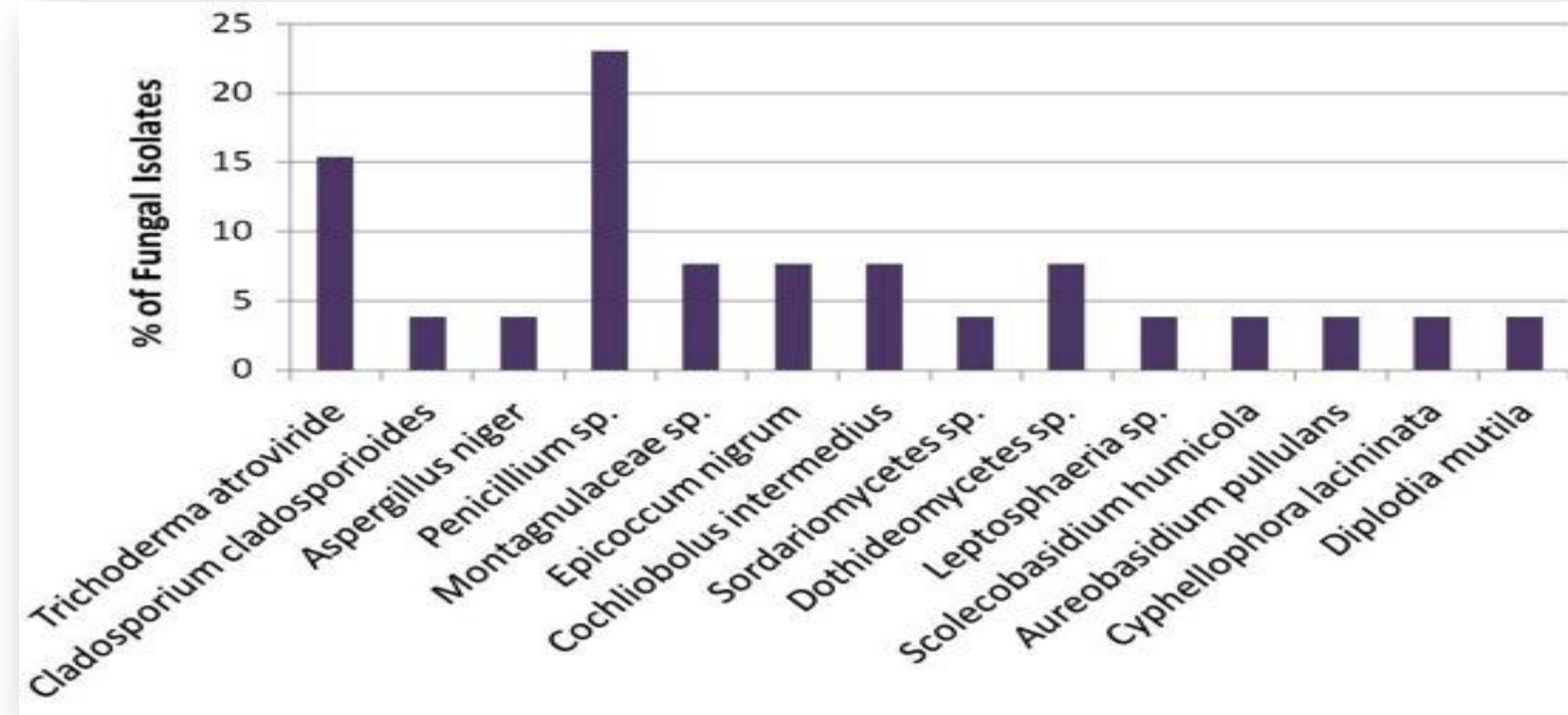


Accomplishment – Microbial Field Sampling Protocol



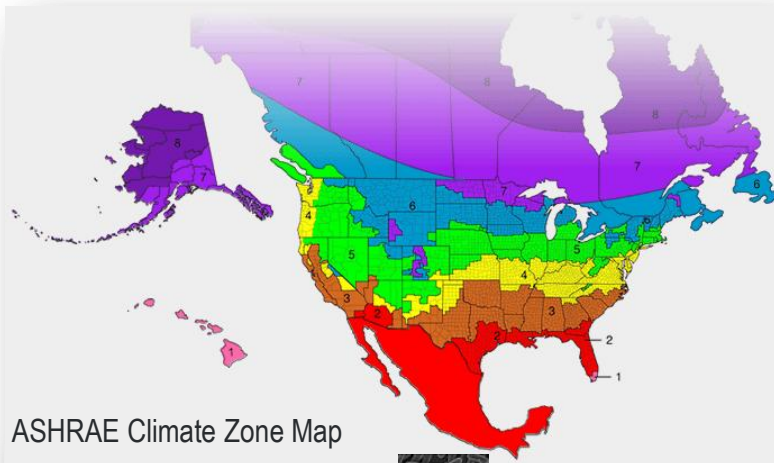
- A field microbial sampling protocol was developed.
- The protocol was applied to a number of cool roofing materials and coatings.
- Protocol was distributed widely and freely to industrial partners.

Accomplishment – Fungal isolate identification

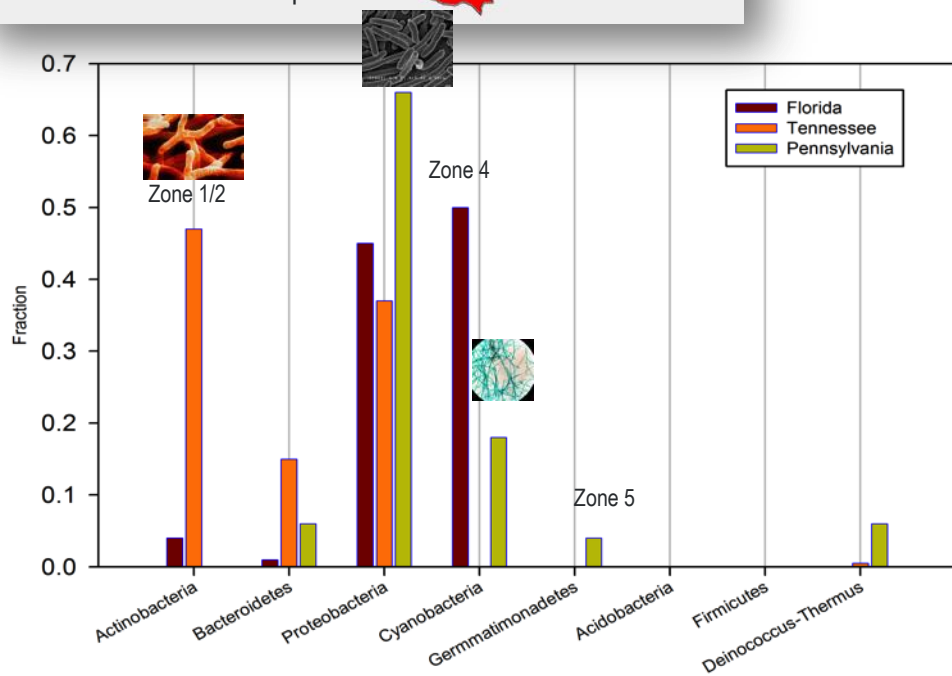


- From the sequenced fungal DNA, 26 were successfully sequenced. NCBI BLAST analysis was used to determine proper fungal genera for each sequenced isolate.
- *Penicillium* was the most dominant fungal genus presented across all locations regardless of environmental and weathering factors.

Accomplishment – Bacterial distribution using 454 pyrosequencing



ASHRAE Climate Zone Map



- FL samples showed much higher abundance of Cyanobacteria/Chloroplast and Proteobacteria.
- TN samples rich in Actinobacteria, Proteobacteria, and other phyla.
- PA samples is dominated by Proteobacteria, followed by cyanobacteria and other phyla.
- Geospatial bacterial diversity is a critical finding.
- 3 separate phyla (categories) could form a start-up bacterial community.

Project Plan & Schedule

Plans and milestones for projects: New Cool Roof Coating Microbial Testing and Cool Color Asphalt Shingles are combined in the schedule.

Summary					Legend											
WBS Number: 19905/22296					Work completed											
Project Number					Active Task											
Agreement Number: BT0304020 and BT0400000					Milestones & Deliverables (Original Plan)											
					Milestones & Deliverables (Actual)											
					FY2012				FY2013				FY2014			
Task/Event					Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
Project Name: New Cool Roof Coatings and Affordable Cool Color Asphalt Shingles																
FY2012: Complete geospatial microbial identification, exposure chamber																
Q1 Milestone: Growth in non-biocide substrate Microbial																
Q1 Milestone: Initiate cost analyses Cool Color Shingles																
Q2 Milestone: Quantification, microincubator design Microbial																
Q2 Milestone: Complete cost analyses Cool Color Shingles																
Current work and future research																
Q3 Milestone: Controlled growth, microincubator fabrication Microbial																
Q3 Milestone: No Activity Cool Color Shingles																
Q4: Quantification, testing protocol development complete Microbial																
Q4: Complete measurement of hygrothermal properties Cool Color Shingles																

Project Budget: FY13 project budget is \$383K.

Variances: No variances from planned budget.

Cost to Date: As of 20 March, \$100K or 26% of budget expended.

Additional Funding: No other funding sources beyond in-kind contributions.

Budget History

FY2010		FY2011		FY2012	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
0	0	\$500K	\$500K	\$600K	\$600K

- **New Cool Roof Coating – Microbial**
 - Microbial cocktail has been assembled
 - ✧ 4 fungal species
 - ✧ 3 algal species
 - ✧ N bacterial species; N remains to be determined
 - Specialized incubator technology has been designed
 - ✧ Optimal growth of each microbial community for precision replica
 - ✧ Continuous growth and growth stimulation allowed
 - ✧ Climatic simulation programmed
- **Cool Color Asphalt Shingles**
 - LBNL model to predict energy savings from retrofit shingle coating
 - All parties contributed to model inputs
 - ✧ Baseline solar reflectance, target solar reflectance, service life
 - Dow and CertainTeed estimated costs of coating
 - ✧ Production and application, reasonable payback period of 5-7 years
 - ✧ Estimated paybacks of 10-15 years exceed what market will absorb

- New Cool Roof Coating – Microbial: Dow, LBNL and ORNL
 - Dow develops more efficient coating
 - LBNL develops accelerated dirt pickup test
 - ORNL develops accelerated microbial test
- Cool Color Asphalt Shingles: Dow, LBNL, CertainTeed and ORNL
 - Dow develops coating and cost data
 - CertainTeed develops coating criteria and market cost data
 - LBNL and ORNL perform cost analyses



Building Solutions



2011

- Cheng, Pfiffner, Miller, and Berdahl (2011) Building and Environment, 46: 999-1010
- Cheng et al. (2011) DOE meeting, Berkeley, CA, July

2012

- Cheng, Miller, New, and Berdahl (2012) Construction and Building Materials, 26: 516-526
- Pfiffner et al. (2012) RRCI Conference, Orlando, FL, February
- Cheng et al. (2012) ASM Conference, San Francisco, CA, June
- Cheng et al. (2012) IRCC Conference, Baltimore, MD, July
- Cheng et al. (2012) COBEE Conference, Boulder, CO, August.
- Pfiffner et al. (2012) ASM KY-TN Branch Meeting, Maryville, TN, October

2013

- Cheng, Cheng, and Pfiffner (2013) Geospatial Characterization of Microbial Communities on Environmentally Aged Roofing Materials, to be submitted to Building and Environment, Status: Internal Review

