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To: Chris Scruton (CEC)

From: Steve Wiel

Subject: **Cool Roof Colored Materials**: Monthly Progress Report for January 2003

cc: Hashem Akbari, Paul Berdahl, André Desjarlais, Ronnen Levinson, Bill Miller

A summary of the status of Tasks and Deliverables as of January 31, 2003 is presented in Attachment 1.

HIGHLIGHTS

- Preparation for March 2003 PAC meeting has started.
- Mike Evans Construction and the Sacramento Municipal Utility District (SMUD) have agreed to participate in the demonstration of cool roof products. Of the various sights we evaluated, we decided to proceed to monitor homes in a Sacramento subdivision being built by Evans.

Tasks

1.1 Attend Kick-Off Meeting
This Task is completed.

1.2 Describe Synergistic Projects
This Task is completed.

2.1 Establish the Project Advisory Committee (PAC)
This task is essentially completed. We have added two new members to the PAC.

2.2 Software Standardization
(No activity.)

2.3 PAC Meetings
Preparation for March 2003 PAC meeting has started.

2.4 Development of Cool Colored Coatings

2.4.1 Identify and Characterize Pigments with High Solar Reflectance
We continued to advance our theory for the determination of pigment properties (scattering coefficient S and absorption coefficient K) from measurements of paint film reflectance and transmittance. Specifically, we have developed a variation on the

standard Kubekla-Munk model that keeps track of beam "diffuseness", or extent to which an incident collimated light beam (such as that generated by a photo-spectrometer) has been diffused by passage through a paint film. The diffuseness is needed to accurately correct measured film reflectances and transmittances for the effects of refractive-index changes at boundaries (e.g., air-film interfaces). Our model relates the diffuseness to the K and S in a manner that may allow us to compute the three unknowns (diffuseness, K, and S) from one reflectance measurement and one transmittance measurement.

We tested amorphous silicon photovoltaic panels (Uni-solar, Ovonic) as examples of cool dark roofing. These panels were bluish-black, with visible reflectance of about 7%. They have an elevated reflectance in the infrared, with overall solar reflectance (direct + diffuse) of 25%. Thus the solar absorptance is only 75% (low for a dark material). Furthermore, about 6% of the absorbed energy can be converted to electricity, reducing the effective solar absorptance to 69%.

We tested two samples of NTT-AT cool dark materials, a green and a brown. The spectral reflectance curves appear different from those measured so far. This is a two-coat system, with a white undercoat. The reflectances are 0.26 for green and 0.35 for brown. NTT-AT: NTT is a large Japanese telecommunications company. AT is the Advanced Technology division. (Contact person: Nobuhiro Funakoshi funakosi@neo.ntt-at.co.jp).

2.4.2 Develop a Computer Program for Optimal Design of Cool Coatings

We have created the basic software for predicting the performance of layered paint films, and employed it to validate computed values of K and S. That is, we use values of K and S computed from the measured reflectance and transmittance of a paint film over a void (that is, with a black body cavity background) to compute the reflectances of the same paint film over both white and black backgrounds. We then compare predicted to measured reflectances. The software will be extended to handle the case of paint mixtures.

2.4.3 Develop a Database of Cool-Colored Pigments

(No activity.)

2.5 Development of Prototype Cool-Colored Roofing Materials

2.5.1 Review of Roofing Materials Manufacturing Methods

We have made arrangements to visit the 3M's granule plant in Corona (near Ontario, CA) and the Elk Shingle manufacturing plant in Shafter (near Bakersfield, CA). The arrangement is for February 18 and 19, 2002. We are also making arrangements with BASF and ISP Minerals to visit a few other industrial sites (manufacturing of roofing materials) in the vicinity of the Bay Area.

2.5.2 Design Innovative Methods for Application of Cool Coatings to Roofing Materials

No significant progress in January.

2.5.3 Accelerated Weathering Testing

(No activity.)

2.6 Field-Testing and Product Useful Life Testing

Mike Evans of Evans Construction has agreed to work and cooperate with us (ORNL), the Sacramento Municipal Utility District (SMUD), and Hanson Roof Tile

for setting up two concrete tile roofs on residential homes located in a Sacramento subdivision. A Memorandum of Understanding was forwarded to Evans for review, which he is agreeable to unless some major unforeseen problem occurs.

Land use agreements were granted for setup of the exposure racks in seven sites across the state of California. The exposure racks are on order and will be delivered to the respective field sites in March 03.

2.6.1 Building Energy-Use Measurements at California Demonstration Sites

The SMUD and ORNL have agreed to work together to instrument the demonstration homes and have developed a common data acquisition system (DAS) for measuring wall, roof and HVAC performance (see Table 1 of Attachment). SMUD has agreed to conduct routine maintenance of the DAS systems. We (ORNL) will install all instruments with exception of the watt-hour meters, which SMUD will install to measure total and HVAC power draws for each house.

Evans Construction is making revisions to the architectural house plans, and will hire in late February a decorator to help with selection of colors. Once the color scheme is selected we can precede to make and deliver the tile and metal roof materials. Hanson Tile is working with Ferro Corp. to blend a color in advance of fabricating the roof test materials. Blending the complex inorganic color pigments into the Portland cement and sand mixture may prove difficult because of the volume of pigment required to achieve a high reflectance. Rather than blend the complex inorganic pigments into the concrete mix, we may need to concentrate the pigments near the surface in a coating. Therefore, we are proceeding to determine the best application technique.

2.6.2 Materials Testing at Weathering Farms in California

A MOU was forwarded to Kent Frame of the California Department of Water Resources to define placement and maintenance requirements for exposure rack sets placed in the vicinity of CIMIS sites in Shasta and Imperial counties.

The exposure rack sets are on order and will be delivered March 03 to the exposure sites. Each exposure rack set is divided into three mainframe sections having respective slopes of 2-, 4- and 8-in of rise for 12-in of run. Each main frame will support two “Sure Grip” sub-frame assemblies. The “Sure Grip” assemblies are easily installed and removed from a main frame, and each assembly will support 5 rows of samples with each row holding up to 10 samples. Therefore, the exposure rack sets will have sufficient room for additional asphalt shingles and wood shake samples when they are ready for exposure testing. All samples will be no larger than 3.5-in by 3.5-in, a size that LBNL's Perkin-Elmer Lambda 900 spectrophotometer can easily accommodate.

MCA will supply samples of clay tile, and MonierLife Tile will supply the cement tile samples. For surface consistency and ease of reflectance measurements, MonierLife will use flat concrete tiles to make their samples. BASF has agreed to supply all the painted metal samples, and will send painted metal chips to Shepherd Color Company, MonierLife Tile and MCA for selecting similar colors as compared to the painted metal samples. MCA has a palette of colors in clay tile and it will be easy to select similar colors; however, MCA manufacturers clay tiles only with the CRCM. Shepherd Color Company and Jerry Vandewater of MonierLife Tile will work together to develop the different color CRCM tile samples.

2.6.3 Steep-Slope Assembly Testing at ORNL

Miller attended the Cool Metal Roofing Coalition (CMRC) meeting in January, 03 and finalized the agreement with the metal roof participants to use the existing steep-slope assembly for testing clay, tile and painted metal roofs having CRCM. The Roof Tile Institute (RTI) wants ORNL to measure the cool roof properties of five different tile assemblies that includes high profile "S" mission installed directly to the deck and over a batten and flat concrete tiles installed over a counter batten. ORNL made a commitment to test two metal roofs, one with and one without CRCM. We will, therefore, add two additional test lanes onto the existing assembly to accommodate testing of the painted metal materials. The painted metals will be direct nailed to the roof deck.

2.6.4 Product Useful Life Testing

(No activity.)

2.7 Technology transfer and market plan

2.7.1 Technology Transfer

John Lund of Ferro Corporation, on behalf of ORNL, presented the paper "PVDF Coatings with Special IR Reflective Pigments" at the Fluorine in Coatings V conference held in Orlando, FL on January 21, 2003. The Paint Research Association (PRA) International Center for Coatings Technology hosted the conference. The presentation addressed the physics of CRCM in boosting reflectance and highlighted the fade resistance for two-years of weathering of complex inorganic color pigments used in painted polyvinylidene fluoride coatings applied to painted metal.

2.7.2 Market Plan

(No activity.)

2.7.3 Title 24 Code Revisions

(No activity.)

Management Issues

- None

Attachment 1

Project Tasks and Schedules (*Approved on May 16, 2002*)

Task	Task Title and Deliverables	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 01/31/2003
1	**Preliminary Activities**					
1.1	Attend Kick Off Meeting *Deliverables:* • Written documentation of meeting agreements and all pertinent information (**Completed**) • Initial schedule for the Project Advisory Committee meetings (**Completed**) • Initial schedule for the Critical Project Reviews (**Completed**)	5/16/02	5/16/02	6/1/02	6/10/02	100%
1.2	Describe Synergistic Projects *Deliverables:* • A list of relevant on-going projects at LBNL and ORNL (**Completed**)	5/1/02	2/1/02	5/1/02	5/1/02	100%
1.3	Identify Required Permits	N/A		N/A		
1.4	Obtain Required Permits	N/A		N/A		
1.5	Prepare Production Readiness Plan	N/A		N/A		
2	**Technical Tasks**					
2.1	Establish the project advisory committee *Deliverables:* • Proposed Initial PAC Organization Membership List (**Completed**) • Final Initial PAC Organization Membership List • PAC Meeting Schedule (**Completed)** • Letters of Acceptance	6/1/02	5/17/02	9/1/02		98%
2.2	Software standardization *Deliverables:* • When applicable, all reports will include additional file formats that will be necessary to transfer deliverables to the CEC • When applicable, all reports will include lists of the computer platforms, operating systems and software required to review upcoming software deliverables	N/A		N/A		

Project Tasks and Schedules (contd.)

Task	Task Title and Deliverables	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 1/31/2003
2.3	PAC meetings *Deliverables:* • Draft PAC meeting agenda(s) with back-up materials for agenda itemsFinal PAC meeting agenda(s) with back-up materials for agenda items Schedule of Critical Project ReviewsDraft PAC Meeting Summaries • Final PAC Meeting Summaries	9/1/02	6/1/02	6/1/05		15% (1/6)
2.4	Development of cool colored coatings					
2.4.1	Identify and Characterize Pigments with High Solar Reflectance *Deliverables:* • Pigment Characterization Data Report	6/1/02	6/1/02	12/1/04		~ 20%
2.4.2	Develop a Computer Program for Optimal Design of Cool Coatings *Deliverables:* • Computer Program	11/1/03		12/1/04		
2.4.3	Develop a Database of Cool-Colored Pigments *Deliverables:* • Electronic-format Pigment Database	6/1/03		6/1/05		
2.5	Development of prototype cool-colored roofing materials					
2.5.1	Review of Roofing Materials Manufacturing Methods *Deliverables:* • Methods of Fabrication and Coloring Report	6/1/02	6/1/02	6/1/03		~ 45%
2.5.2	Design Innovative Methods for Application of Cool Coatings to Roofing Materials *Deliverables:* • Summary Coating Report • Prototype Performance Report	6/1/02	6/1/02	12/1/04		< 5%
2.5.3	Accelerated Weathering Testing *Deliverables:* • Accelerated Weathering Testing Report	11/1/02	10/1/02	6/1/05		< 3%

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 1/31/2003
2.6	Field-testing and product useful life testing					
2.6.1	Building Energy-Use Measurements at California Demonstration Sites *Deliverables:* • Demonstration Site Test Plan • Test Site Report	6/1/02	9/1/02	10/1/05		7%
2.6.2	Materials Testing at Weathering Farms in California *Deliverables:* • Weathering Studies Report	6/1/02	10/1/02	10/1/05		12%
2.6.3	Steep-slope Assembly Testing at ORNL *Deliverables:* • Whole-Building Energy Model Validation Presentation at the Pacific Coast Builders ConferenceSteep Slope Assembly Test Report	6/1/02	10/1/02	10/1/05		~ 12%
2.6.4	Product Useful Life Testing *Deliverables:* • Solar Reflectance Test Report	5/1/04		6/1/05		
2.7	Technology transfer and market plan					
2.7.1	Technology Transfer *Deliverables:* • Publication of results in industry magazines and refereed journal articles • Participation in buildings products exhibition, such as the PCBC Brochure summarizing research results and characterizing the benefits of cool colored roofing materials	6/1/03	6/1/02	6/1/05		~ 3%
2.7.2	Market Plan *Deliverables:* • Market Plan(s)	5/1/05		6/1/05		
2.7.3	Title 24 Code Revisions *Deliverables:* • Document coordination with Cool Roofs Rating Council in monthly progress reports • Title 24 Database	6/1/02	5/16/02	6/1/05		~ 5%

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of 1/31/2003
VII	Critical Project Review(s) *Deliverables:* • Minutes of the CPR meeting					
XII (C)	Monthly Progress Reports *Deliverables:* • Monthly Progress Reports	6/1/02	6/1/02	6/1/05		22% (8/36)
XII (D)	Final Report *Deliverables:* • Final Report Outline • Final Report	3/1/05		10/1/05		
	Final Meeting *Deliverables:* • Minutes of the CPR meeting	10/15/05		10/31/05		

February 13, 2003

Table 1. Instrumentation and Data Acquisition Systems.

Instrument	Description	Number	Signal	Location	Attachment
					East Facing Roof
Thermocouple (Type T Cu/Con)	Unshielded bead	1	mv	Deck	Taped
	Unshielded bead	1	mv	Deck	Embedded between OSBs
Heat Flux Transducer Bismuth Telluride	2-in by 2-in by 0.125-in thick	1	mv	Deck	Embedded between OSBs
Anemometer	Probe	1	pulse	Near HFT	Mounting bracket
Pyranometer Li-Cor	Probe	1	μa	Near HFT	Mounting bracket
Thermocouple (Type T Cu/Con)	Unshielded bead	1	mv	Deck underside	Taped
	30 AWG Unshielded bead		mv	Spare for Roof Surface	Loctite Epoxy
					West Facing Roof
Thermocouple (Type T Cu/Con)	Unshielded bead	1	mv	Deck	Taped
	Unshielded bead	1	mv	Deck	Embedded between OSBs
Heat Flux Transducer Bismuth Telluride	2-in by 2-in by 0.125-in thick	1	mv	Deck	Embedded between OSBs
Anemometer	Probe	1	pulse	Near HFT	Mounting bracket
Pyranometer Li-Cor	Probe	1	μa	Near HFT	Mounting bracket
Thermocouple (Type T Cu/Con)	Unshielded bead	1	mv	Deck underside	Taped
	30 AWG Unshielded bead		mv	Spare for Roof Surface	Loctite Epoxy
					Attic interior
Vaisala 50Y	DB & RH Probe	1	ma	Attic air 4-ft above insulation	Run along support wire
Thermocouple (Type T Cu/Con)	Shielded bead	1	mv	Top of insulation	Laid atop insulation
	Unshielded bead	1	mv	Sheet rock surface facing attic	Taped
Heat Flux Transducer Bismuth Telluride	2-in by 2-in by 0.125-in thick	1	mv	Sheet rock surface facing attic	Sandwiched between insulation and sheet rock
					House interior
Vaisala 50Y	DB & RH Probe	1	ma	Entering return grill	Duct mounted
Watt-hour meter	Form 16S kWHr	1	pulse	Total	Meter base, hub & box
Watt-hour meter	Form 16S kWHr	1	pulse	HVAC	Meter base, hub & box
					Roof Ridge
Vaisala 50Y	DB & RH Probe	1	ma	Attic air 4-ft above insulation	Mounting bracket
Totals					

Thermocouples		8
Heat Flux Transducers		3
DB/RH Probe		3
Anemometer		2
Pyranometer		2
Watt-hour meter		2
Total Instruments		**23**