



ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Stephen Wiel, Head
Energy Analysis Department
Environmental Energy Technologies Division

MS 90-4000
1 Cyclotron Rd.
Berkeley, CA 94720

Tel: 510-486-5396
Fax: 510-486-6996
e-mail: Swiel@lbl.gov

September 10, 2002

To: Chris Scruton (CEC)
From: Steve Wiel
Subject: **Cool Roof Colored Materials**: Monthly Progress Report for August 2002
CC: Hashem Akbari, Paul Berdahl, Andre Desjarlais, Bill Miller, Ronnen Levinson

A summary of the status of Tasks and Deliverables as of August 31, 2002 is presented in Attachment 1.

HIGHLIGHTS

- All of our eight invited industrial partners have agreed to join the project by signing and sending a letter of understanding to LBNL (Akbari).

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)
We continued to update the list of PAC members with potential new candidates. As of August 31, 2002, nine organizations of the 15 invited have signed up to be a PAC member (see Attachment 2 for the updated list of PAC members). Chris Scruton (CEC Project Manager) has sent formal invitation letters to candidate PAC members. We have organized the first PAC meeting to take place on September 12, 2002 in Sacramento. We also continued working with our potential industrial partners. By August 31, 2002, all partners (Ferro, BASF, Shepherd, GAF, Elk, 3M, ISP, and MCA) signed and sent their letter of understanding to Akbari and have been invited to participate in the PAC meeting.

2.2 Software standardization
(no activity)

2.3 PAC meetings
Arrangements have been made for the first PAC meeting to be held in Sacramento at CEC's office on September 12, 2002. The ORNL and LBNL project team will meet with

the industrial partners at LBNL on the afternoon of September 11, 2002 for final coordination prior to the meeting.

2.4 Development of cool colored coatings

2.4.1 Identify and Characterize Pigments with High Solar Reflectance

We began our characterization of conventional and cool pigments by studying 19 Kynar-based single-pigment paints, 2 clear binders (Kynar and polyester), and a metal primer. We measured four spectral optical properties of each 25-micron-thick, free-standing film: (1) transmittance, (2) reflectance over a black body cavity, (3) reflectance over an opaque black background, and (4) reflectance over an opaque white background. The first two values were used to calculate the spectral absorptance of the 25-micron film, while the latter two values were used to calculate the spectral Kubelka-Munk (K-M) absorption and scattering coefficients that characterize the pigments. We intend to increase the accuracy of our K-M calculations by devising an algorithm that utilizes all four measured properties.

We have observed that even thin (25-micron) films of certain pigments are opaque at some wavelengths of interest, particularly in the visible region. This limits our ability to calculate K-M coefficients, since only one property (opaque reflectance) can be measured at these wavelengths. We will try to determine the K-M coefficients of such pigments by analyzing tint ladders (dilutions with varying amounts of white).

We are enlarging our pigment library by characterizing 24 single-pigment, 6 interference, and 2 iridescent (interference + pigment) acrylic artist paints, along with two clear acrylic binders. Since thin (25-micron) free-standing acrylic films proved too fragile and clingy to handle, we painted 25-micron films on a substrate of 25-micron-thick transparent Mylar-D. We will measure and analyze the acrylic-on-mylar films next month.

2.4.2 Develop a Computer Program for Optimal Design of Cool Coatings (no activity)

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

The review of literature is progressing on schedule. Our industrial partners will be sharing manufacturing process information with us. Akbari is also planning to visit a few 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 activity)

2.5.3 Accelerated Weathering Testing (no activity)

2.6 Field-testing and product useful life testing

2.6.1 Building Energy-Use Measurements at California Demonstration Sites

A written test plan was prepared for the proposed approach to setup and test “Cool Roof Colored Materials” (CRCM) at the California demonstration sites, at ORNL on the Envelope Systems Research Apparatus (ESRA) and at the California weathering farms. ORNL with assistance from LBNL and in conjunction with pigment (colorant) manufacturers will select appropriate CRCMs, apply them to roofing materials and field test the roof products at up to eight demonstration homes in Sacramento, CA., at weathering farms located in seven of the sixteen climatic zones in California, and at the ESRA on a steep-slope assembly. Our objective is to catalog temperature, heat transmission, reflectance, emittance and color fastness data for cool asphalt shingle, tile, metal and wood shake roofs and use the data to formulate and validate design tools for predicting the roof energy load during the cooling and heating seasons for residential buildings that use CRCM. Participants from LBNL, the Florida Solar Research Center and the project technical manager at the CEC will be sent the test plan for review and comment during the next reporting period.

2.6.2 Materials Testing at Weathering Farms in California

A test plan has been prepared; see Task 2.6.1.

2.6.3 Steep-slope Assembly Testing at ORNL

Efforts have begun to design the steep-slope assembly for testing tile, metal and wood shake roof sections on the ESRA. Because the assembly will support several lanes of tile roofing, a stress analysis is being conducted to determine whether additional support strength is needed in the existing roof purlins. The steep-slope assembly will have five of its eight new test lanes in tile roofing, three of which will use CRCM while the other two will have traditional red, green, or brown colors. One of the two traditional tile assemblies will be direct-nailed (un-vented) while the other four tile assemblies will be vented through counter-batten installation. The remaining lanes will be covered in metal and wood shake CRCM roofs. The participants supplying the metal and or wood shake roofs will decided the appropriate venting.

2.6.4 Product Useful Life Testing (no activity)

2.7 Technology transfer and market plan

2.7.1 Technology Transfer

A paper “Cool Color Roofs with Complex Inorganic Color Pigments” was presented at the American Council for an Energy Efficient Economy 2002 Summer Study. The paper addressed preliminary findings of the surface properties causing cool pigmented colors to reflect infrared radiation. Accelerated weather testing using natural sunlight and xenon-arc weatherometer exposure showed that color changes in the cool pigmented colors were indistinguishable from their original color, even after one year of field exposure and 5000 hours of xenon-arc exposure.

The paper announced the collaborative CEC-sponsored efforts of LBNL and ORNL in conjunction with pigment (colorant) manufacturers to make cool pigmented color asphalt shingles, roofing tiles, metal roofing, wood shakes, roofing membranes, and roof coatings a market reality within three to five years in the roofing industry.

2.7.2 Market Plan
(no activity)

2.7.3 Title 24 Code Revisions

On August 27, 2002, Akbari presented a code change proposal to CEC Title 24 to modify prescriptive requirements for low-sloped (flat) non-residential roofs.

Management Issues

- The Buildings Technology Center (BTC) of ORNL is letting a contract with Dr. Majid Keyhani of the Mechanical Engineering Department of the University of Tennessee to support ORNL's work in the "Cool Roof Colored Materials" (CRCM) project. The contract provides for the services of Dr. Majid Keyhani and a doctorate candidate, Mr. Ron Domitrovic, to study the combined effect of forced and natural convection heat transfer, termed mixed convection, that occurs in the vented air gap on the underside of a tile or metal roof.

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 August 31, 2002
1.1	Attend Kick Off Meeting <i>Deliverables:</i> <ul style="list-style-type: none"> 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 <i>Deliverables:</i> <ul style="list-style-type: none"> 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		
2.1	Establish the project advisory committee <i>Deliverables:</i> <ul style="list-style-type: none"> 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		95%
2.2	Software standardization <i>Deliverables:</i> <ul style="list-style-type: none"> When applicable, all reports shall include additional file formats that will be necessary to transfer deliverables to the CEC When applicable, all reports shall 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 August 31, 2002
2.3	PAC meetings <i>Deliverables:</i> <ul style="list-style-type: none"> Draft PAC meeting agenda(s) with back-up materials for agenda items Final PAC meeting agenda(s) with back-up materials for agenda items Schedule of Critical Project Reviews Draft PAC Meeting Summaries Final PAC Meeting Summaries 	9/1/02		6/1/05		
2.4	Development of cool colored coatings					
2.4.1	Identify and Characterize Pigments with High Solar Reflectance <i>Deliverables:</i> <ul style="list-style-type: none"> Pigment Characterization Data Report 	6/1/02	6/1/02	12/1/04		~ 5%
2.4.2	Develop a Computer Program for Optimal Design of Cool Coatings <i>Deliverables:</i> <ul style="list-style-type: none"> Computer Program 	11/1/03		12/1/04		
2.4.3	Develop a Database of Cool-Colored Pigments <i>Deliverables:</i> <ul style="list-style-type: none"> 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 <i>Deliverables:</i> <ul style="list-style-type: none"> Methods of Fabrication and Coloring Report 	6/1/02	6/1/02	6/1/03		~ 5%
2.5.2	Design Innovative Methods for Application of Cool Coatings to Roofing Materials <i>Deliverables:</i> <ul style="list-style-type: none"> Summary Coating Report Prototype Performance Report 	6/1/02		12/1/04		
2.5.3	Accelerated Weathering Testing <i>Deliverables:</i> <ul style="list-style-type: none"> Accelerated Weathering Testing Report 	11/1/02		6/1/05		

Project Tasks and Schedules (contd.)

Task	Task Title	Plan Start Date	Actual Start Date	Plan Finish Date	Actual Finish Date	% Completion as of August 31, 2002
2.6	Field-testing and product useful life testing					
2.6.1	Building Energy-Use Measurements at California Demonstration Sites <i>Deliverables:</i> <ul style="list-style-type: none"> Demonstration Site Test Plan Test Site Report 	6/1/02		10/1/05		
2.6.2	Materials Testing at Weathering Farms in California <i>Deliverables:</i> <ul style="list-style-type: none"> Weathering Studies Report 	6/1/02		10/1/05		
2.6.3	Steep-slope Assembly Testing at ORNL <i>Deliverables:</i> <ul style="list-style-type: none"> Whole-Building Energy Model Validation Presentation at the Pacific Coast Builders Conference 	6/1/02		10/1/05		< 5%
2.6.4	Product Useful Life Testing <i>Deliverables:</i> <ul style="list-style-type: none"> Solar Reflectance Test Report 	5/1/04		6/1/05		
2.7	Technology transfer and market plan					
2.7.1	Technology Transfer <i>Deliverables:</i> <ul style="list-style-type: none"> 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		6/1/05		
2.7.2	Market Plan <i>Deliverables:</i> <ul style="list-style-type: none"> Market Plan(s) 	5/1/05		6/1/05		
2.7.3	Title 24 Code Revisions <i>Deliverables:</i> <ul style="list-style-type: none"> Document coordination with Cool Roofs Rating Council in monthly progress reports Title 24 Database 	6/1/02	5/16/02	6/1/05		~ 5%

Attachment 2

**Cool Roof Colored Materials
Project Advisory Committee Members**

Member	Company	E mail	Tel No.
Tom Bollnow	National Roofing Contractors Association	tbollnow@nrca.net	847-299-9070
Carl Blumstein (or Jim Cole) CIEE Director	CIEE	blumstei@socrates.berkeley.edu	510-287-3320 (865-8827)
Jack Colbourn Director	EPA SF Office	colbourn.jack@epa.gov	415-947-4109
Noah Horowitz CRRC Ex-Director	CRRC	nhorowitz@nrdc.org	415-777-0220
Archie Mulligan Executive Director	Habitat for Humanity	hfh@calweb.com	T916-456-9543 F916-456-5449
Rick Olson	Roof Tile Institute	ntrma@aol.com	T 888-321-9236 F 541-689-5530
Steven Ryan Energy Star	EPA	Ryan.Steven@epamail.epa.gov	202-564-1254
Mike Rothenberg Program Manager	Bay Area Air Quality Management District	mrothenberg@baaqmd.gov	415-749-4668
Tom Shallow	Asphalt Roofing Manufacturers Association	tshallow@kellencompany.com	202-207-1110

**Cool Roof Colored Materials
Project Advisory Committee Members**

- 1. Carl Blumstein
(or Jim Cole)**
Director
California Institute for Energy Efficiency
UCOP
1333 Broadway, MS 713948
Oakland, CA 94612
Carl: 510-287-3320
Jim: (510-865-8827)
blumstei@socrates.berkeley.edu
JWCole@lbl.gov
- 2. Tom Bollnow**
National Roofing Contractors Association
10255 W. Higgins Rd., Ste. 600
Rosemont, IL 60018-5607
Tel: 847-299-9070
Fax: 847-299-1926
tbollnow@nrca.net
- 3. Jack Colbourn**
Director
EPA SF Office
75 Hawthorne Street
San Francisco, CA 94105
415-947-4109
colbourn.jack@epa.gov
- 4. Noah Horowitz**
CRRC Ex-Director
CRRC
c/o NRDC
71 Stevenson Street, Suite 1825
San Francisco, CA 94105
415-777-0220
nhorowitz@nrdc.org
- 5. Archie Mulligan**
Executive Director
Habitat for Humanity
- 890 Morse Avenue
Sacramento, CA 95864-4922
T916-456-9543
F916-456-5449
hfh@calweb.com
- 6. Rick Olson**
Roof Tile Institute
35524 Zepher Way
Pleasant Hill, OR 97455
Tel: 888-321-9236
Fax: 541-689-5530
ntrma@aol.com
- 7. Mike Rothenberg**
Program Manager
Bay Area Air Quality Management
District
939 Ellis Street
San Francisco, CA 94109
415-749-4668
mrothenberg@baaqmd.gov
- 8. Steven Ryan**
Energy Star
EPA
Ariel Rios Building
1200 Independence Avenue NW
Washington, DC 20460
202-564-1254
Ryan.Steven@epamail.epa.gov
- 9. Thomas A. Shallow**
Asphalt Roofing Manufacturers
Association
1156 15th Street, NW Suite 900
Tel: 202-207-1110
Fax: 202-223-9741
Washington, DC 20005
tshallow@kellencompany.com