A novel technique for the production of cool colored concrete tile and asphalt shingle roofing products

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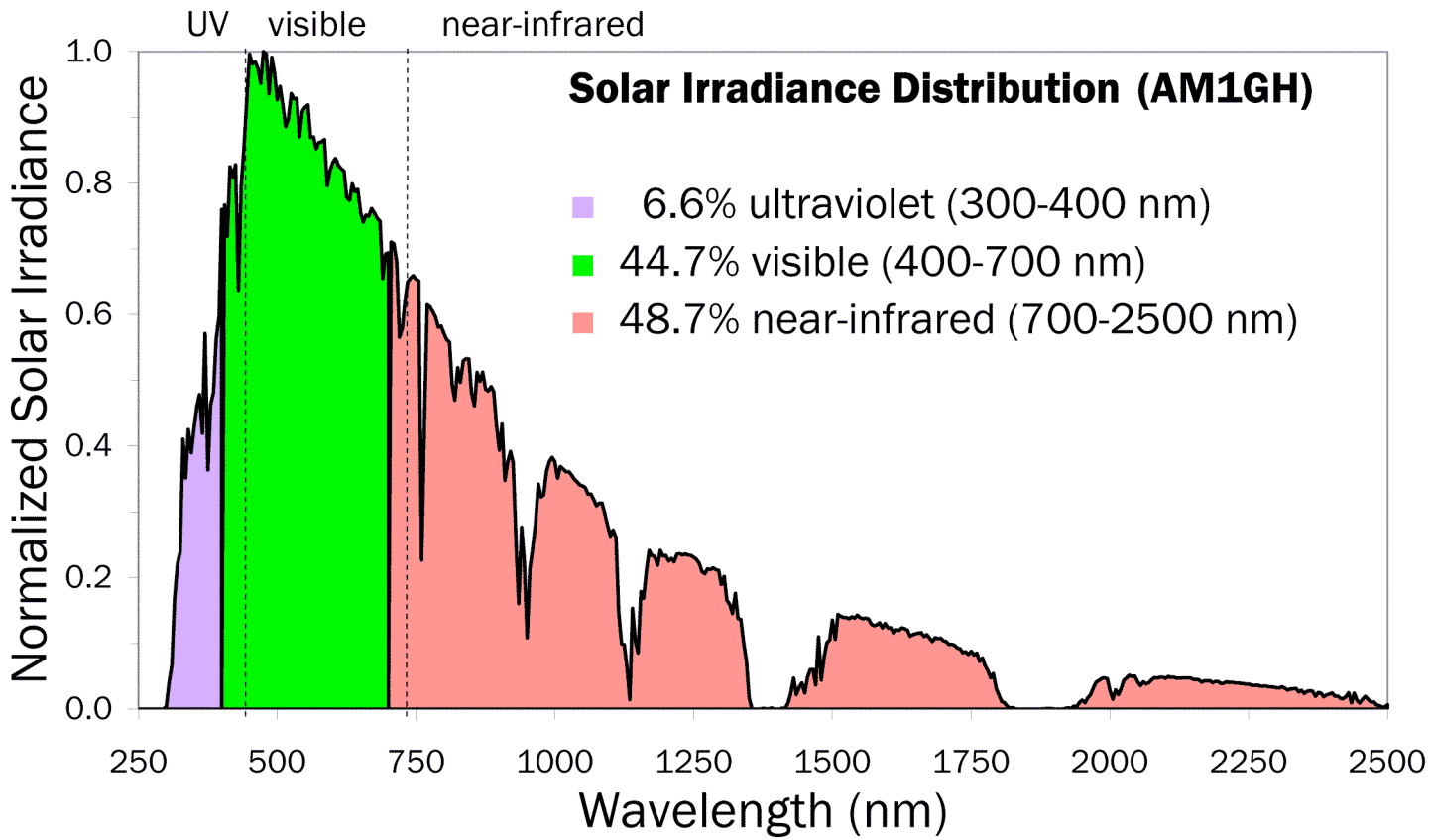
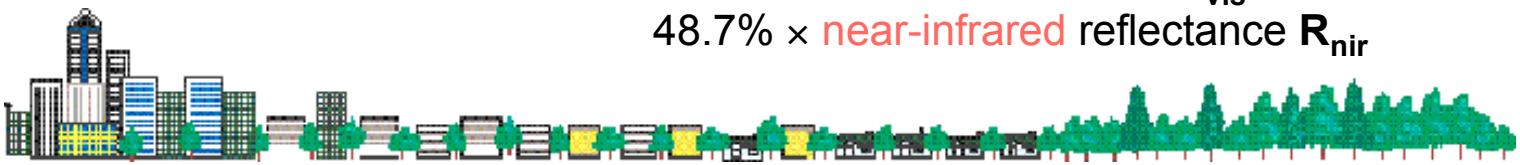
Sunlight — more than meets the eye



AM1GH =
(clear sky)
air mass 1
global horizontal

Solar reflectance $\mathbf{R_{sol}}$ = 6.6% × ultraviolet reflectance $\mathbf{R_{uv}}$ +
44.7% × visible reflectance $\mathbf{R_{vis}}$ +
48.7% × near-infrared reflectance $\mathbf{R_{nir}}$



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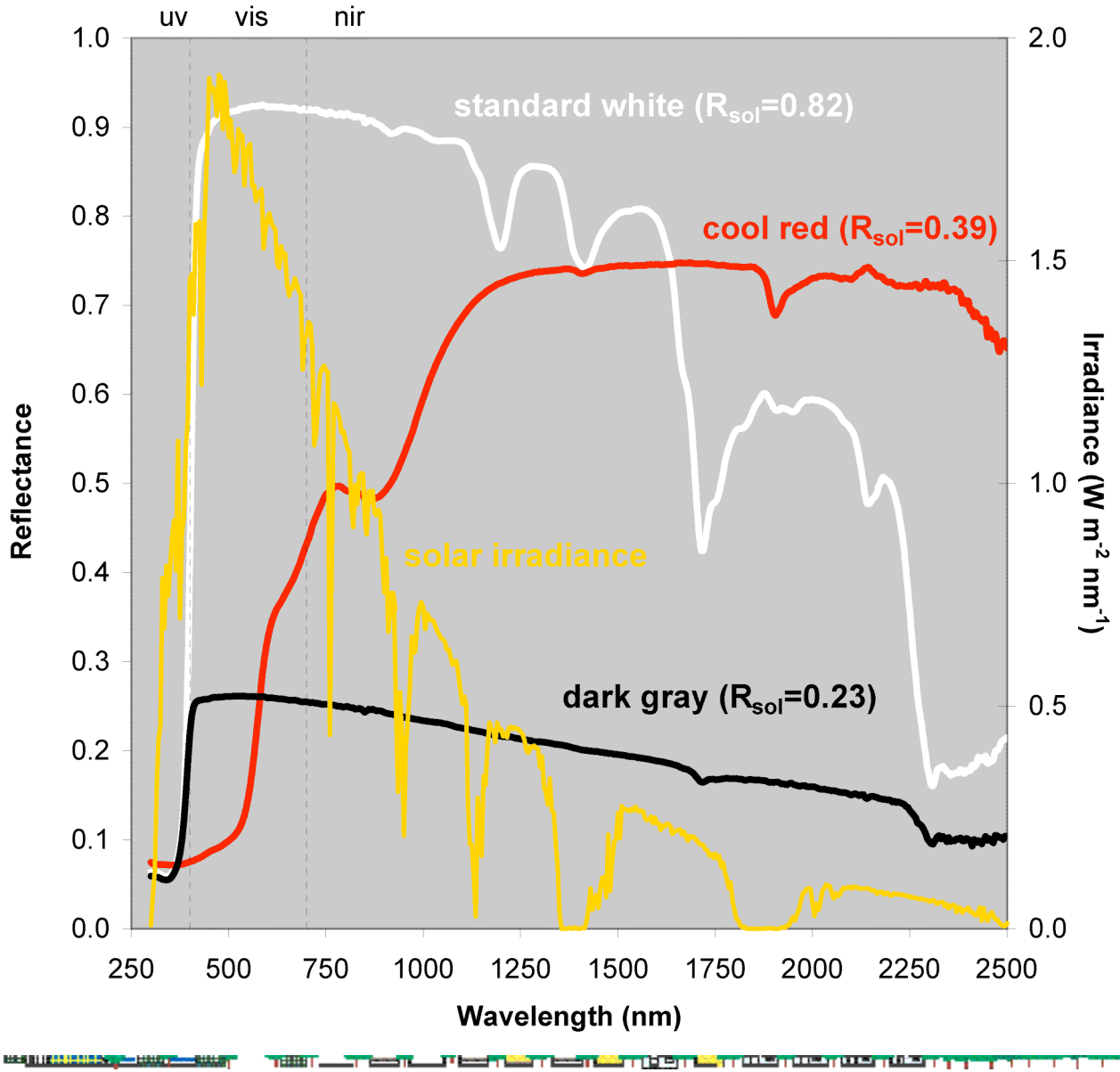
White, cool color, warm color



white roof

cool red roof

gray roof

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Conventional methods for coloring concrete tiles

- Gray-cement concrete
  - low NIR reflectance
- Coloring techniques
  - integrated color
  - cementitious slurry coating
- Limitations
  - gray cement + cool pigment → dark hot color
  - white cement + cool pigment → light cool color

integrated color (SR = 0.15)

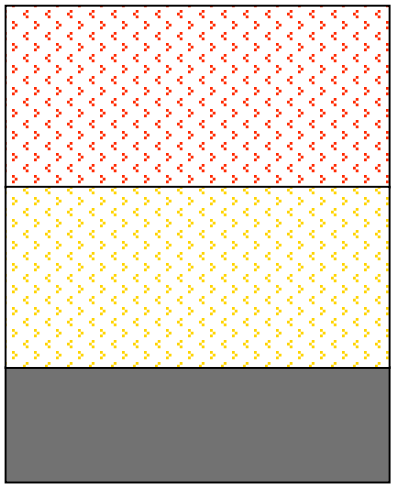
slurry coating (SR = 0.30)

R_{sol} = SR = S = R = solar reflectance

Alternative approach to coloring concrete tiles

- Two-layer polymer coating
  - white basecoat
  - cool color topcoat
  - layering → dark cool color
- Technique already used for tile retrofit coatings
- New process intended for factory line
  - Kynar Aquatec® aqueous polyvinylidene fluoride (PVDF)/acrylic technology
  - pass under white spray
  - pass under cool color spray
  - thin (~30 μm DFT) pigmented latex coatings dry in seconds near room temperature

two-coat system (for NIR-absorbing substrate)

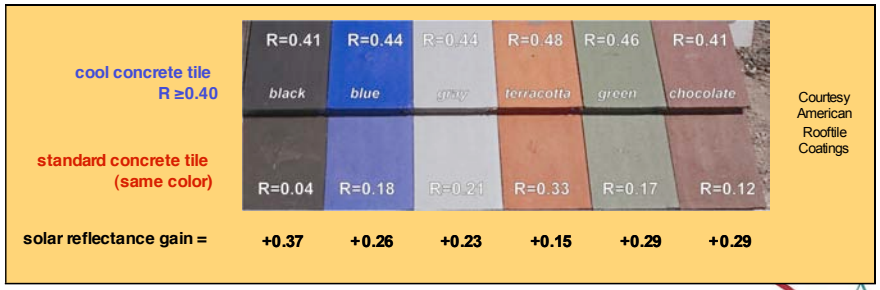


cool topcoat
(e.g., iron oxide red in acrylic)

NIR-reflective basecoat
(e.g., titanium dioxide white in acrylic)

opaque substrate
(e.g., gray concrete or gray granule)

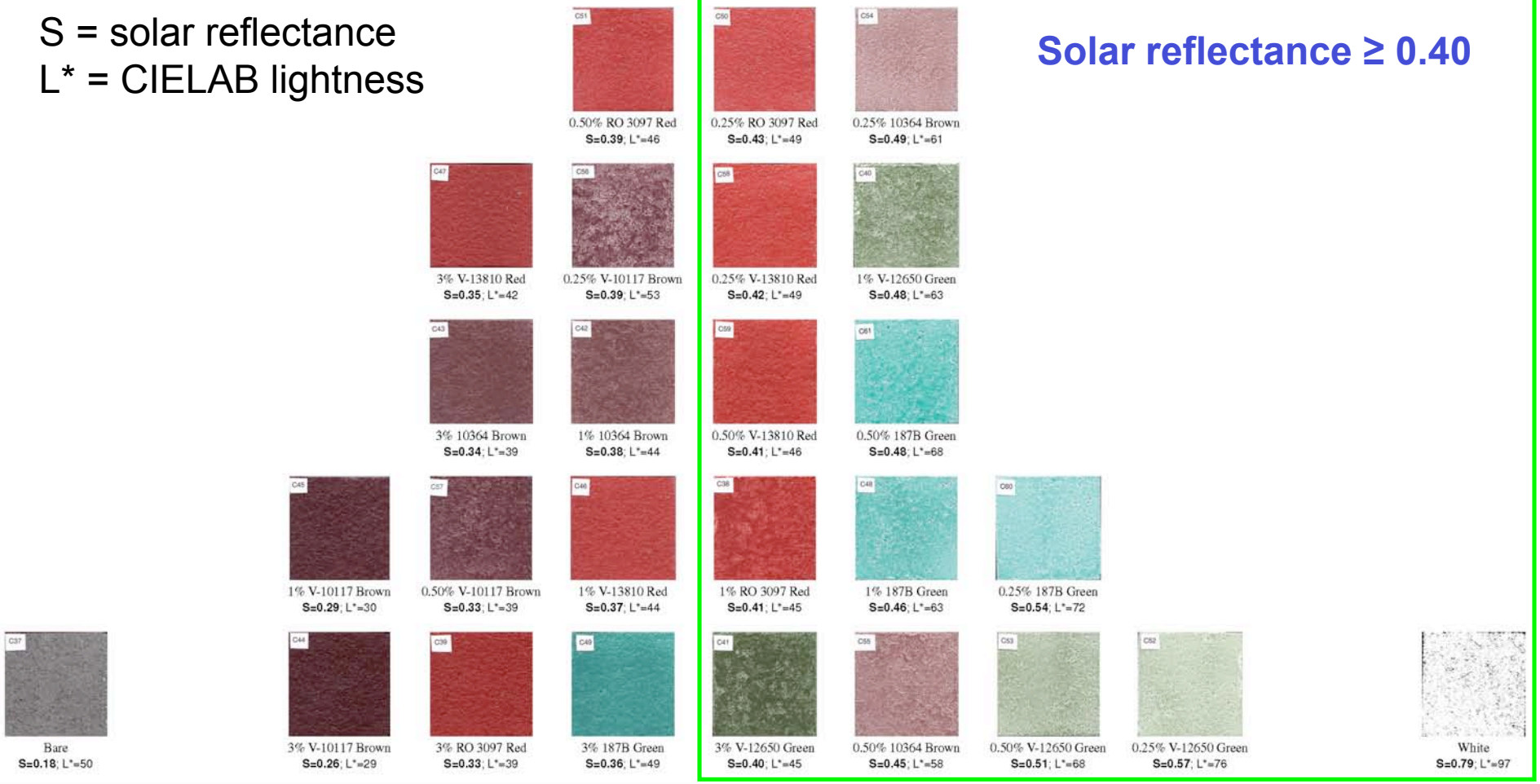
polymer retrofit coatings



Prototype concrete tiles

S = solar reflectance
L* = CIELAB lightness

Solar reflectance ≥ 0.40



S = 0.15 - 0.20 | S = 0.20 - 0.25 | S = 0.25 - 0.30 | S = 0.30 - 0.35 | S = 0.35 - 0.40 | S = 0.40 - 0.45 | S = 0.45 - 0.50 | S = 0.50 - 0.55 | S = 0.55 - 0.60 | . . . | S = 0.75 - 0.80

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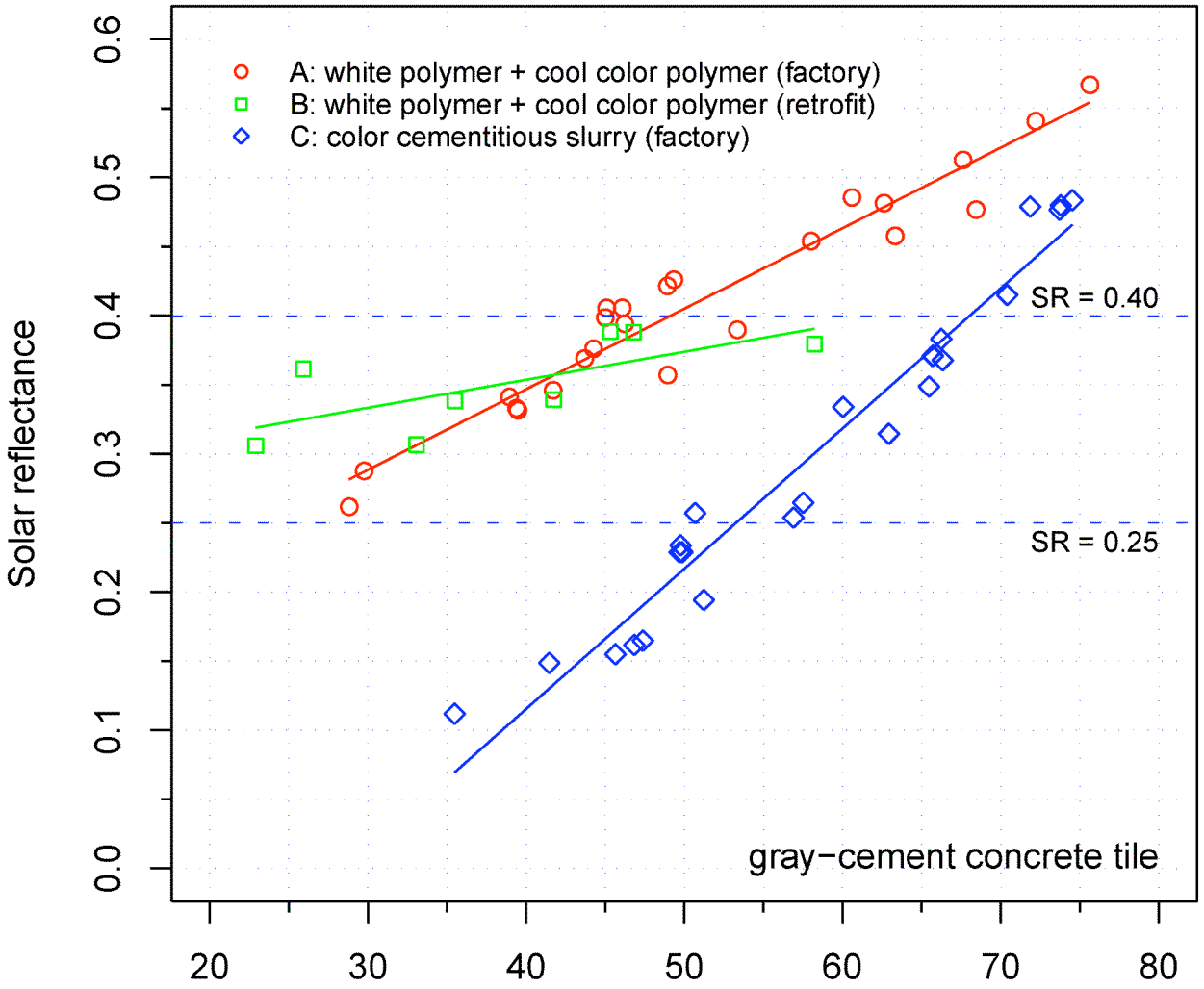
New method yields darker cool colored tiles



Conventional method for coloring asphalt shingles

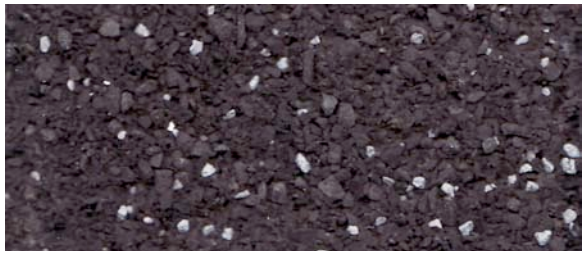
- Fiberglass asphalt shingle = asphalt-saturated fiberglass web fully surfaced with granules
- Granule = crushed gray rock with colored ceramic coating
  - pigmented ceramic coating baked onto granules
  - colored granules pressed into hot asphalt
- Bare granules have low NIR reflectance
- Adding white ceramic basecoat can halve rate of granule production

regular “barkwood” (SR ~ 0.10) without basecoat

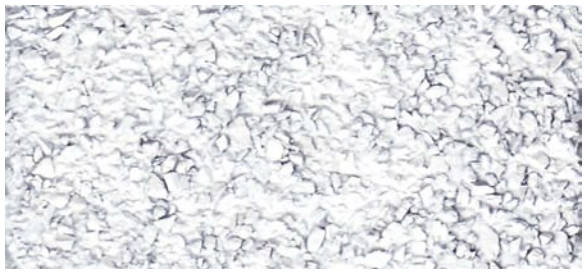
cool “barkwood” (SR ~ 0.25) using ceramic white basecoat

Alternative approach to coloring asphalt shingles

- Two-layer polymer coating (same as for tiles)
- We color granules *after* they have been pressed into shingles
  - coats only exposed side of granules
  - avoids slowing production



bare (SR = 0.06)



white (SR = 0.62)

cool brown over white (SR = 0.30)

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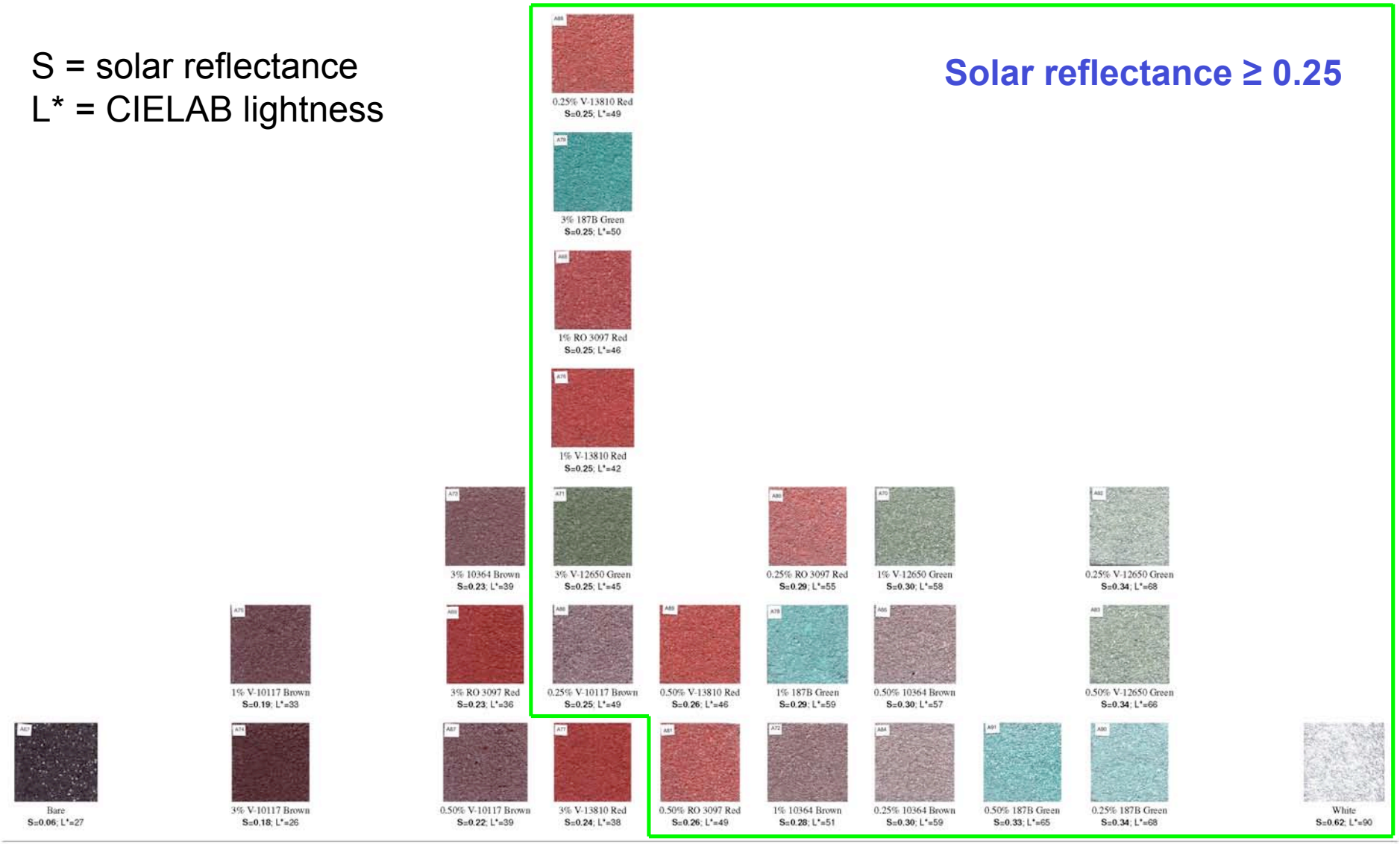
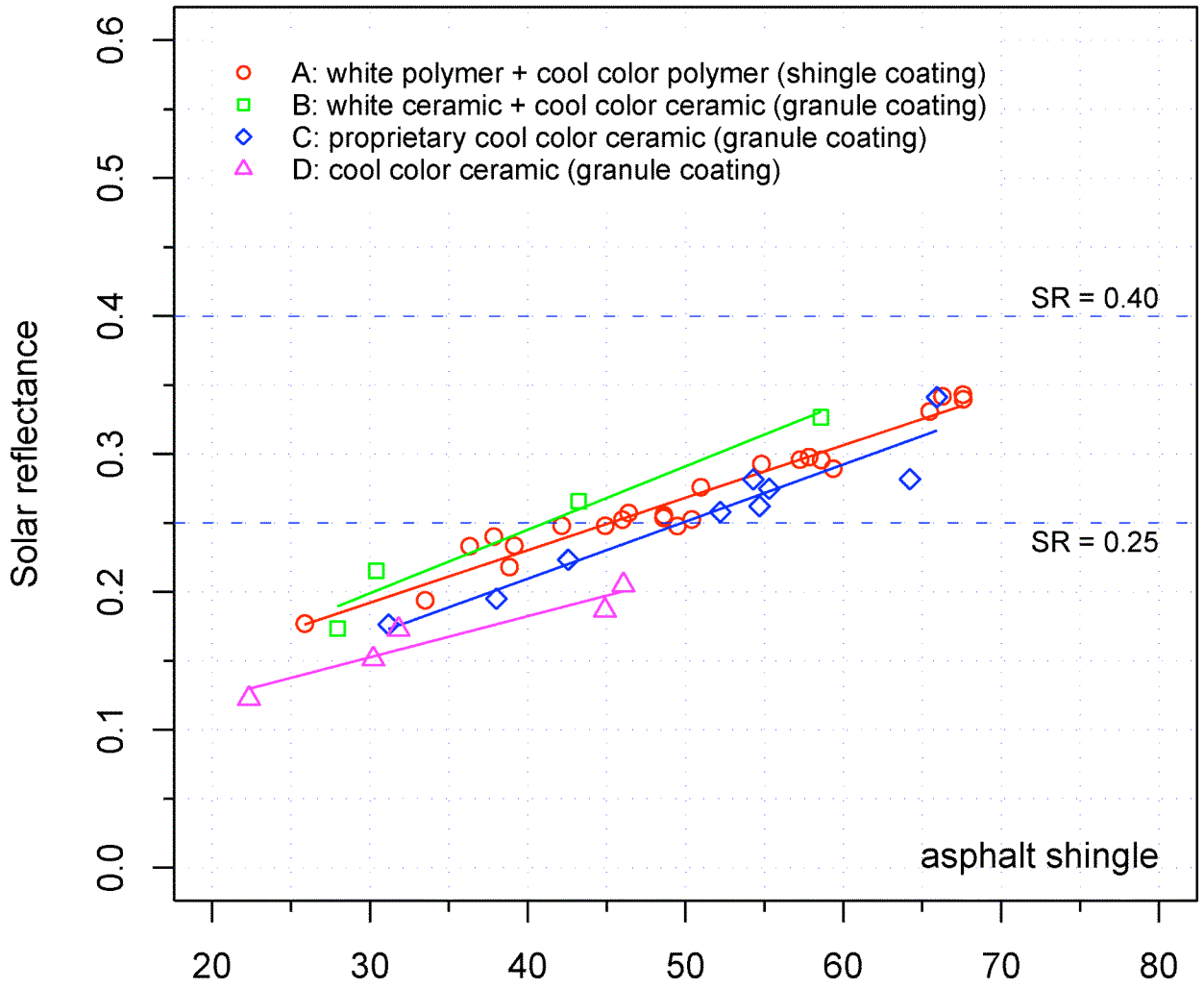
Prototype asphalt shingles

S = solar reflectance
L* = CIELAB lightness

Solar reflectance ≥ 0.25



New method yields darker cool colored shingles



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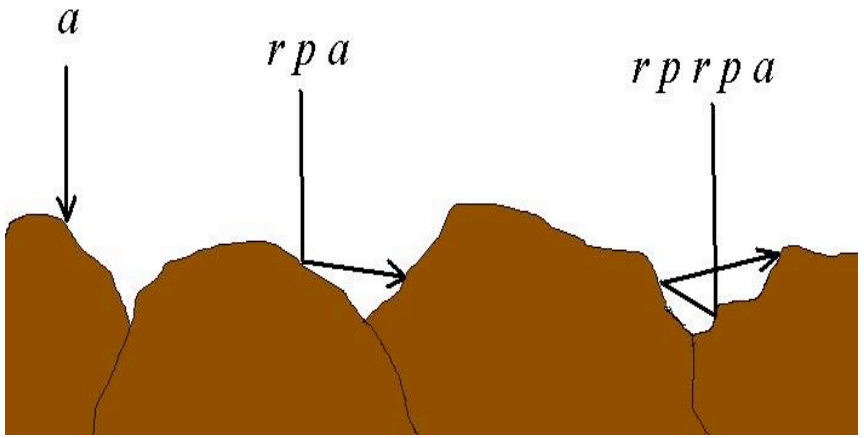
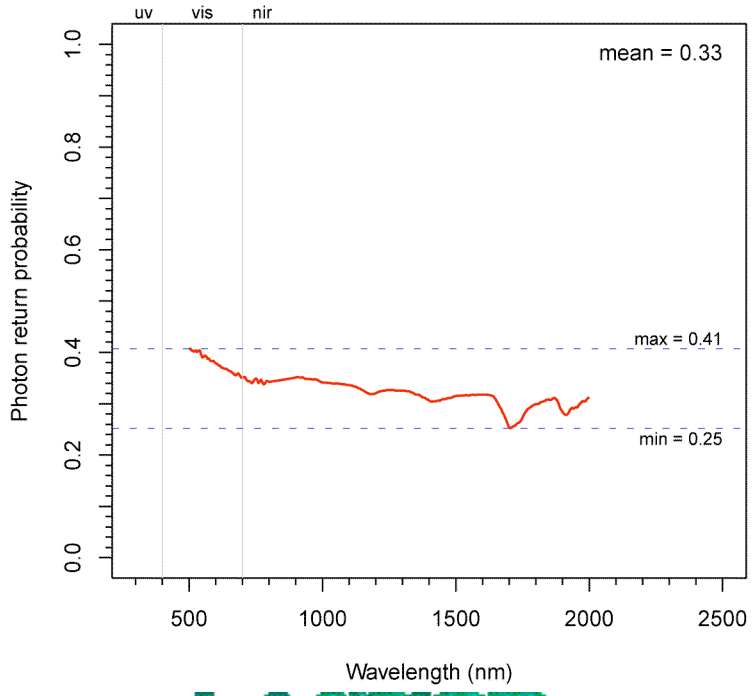
Roughness reduced shingle reflectance

- Some light reflected from rough surface will return
  - for coated shingle, light return probability ~ ⅓
  - light return reduced shingle reflectance by up to 0.10
- Rough surface area ~ 50% greater than footprint area
  - shingle coatings were ~ ⅓ thinner than tile coatings
  - adding 50% more coating could increase shingle solar reflectance by up to 0.12





Summary

- **24 prototype cool color concrete tiles**
  - solar reflectance S ranged from 0.26 to 0.57
  - over half had S ≥ 0.40
- **24 prototype cool color asphalt shingles**
  - S ranged from 0.18 – 0.34
  - over half had S ≥ 0.25
  - could increase S by up to 0.12 by using 50% more coating
- Prototypes darker for given S, or more reflective for given lightness L*
- **Next steps:** explore
  - thicker shingle coatings
  - other cool pigments
  - multicolor coatings
  - patterned coatings
  - factory-line trials

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