

Modeling of Total Solar Reflectance

FIGURE 1—Solar irradiance according to ASTM G 159 (198), air mass 1.5². Standard solar irradiance at the earth's surface corrected for atmospheric absorbance.

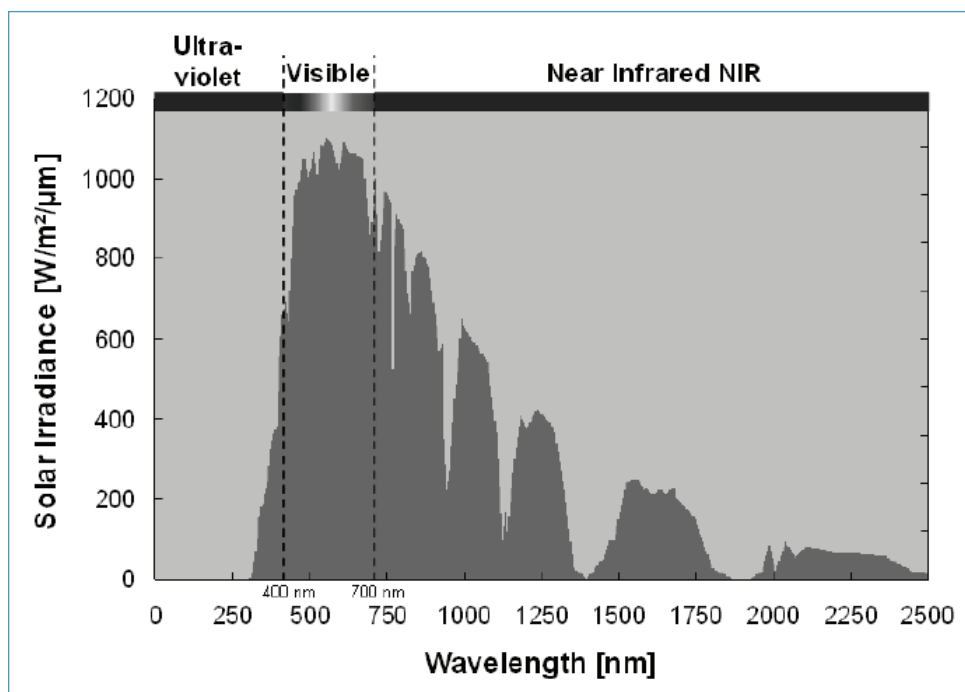


FIGURE 2—Structure of Pigment Black 32 (PBk 32), an NIR-transparent perylene black pigment used to make high solar reflectance coatings.

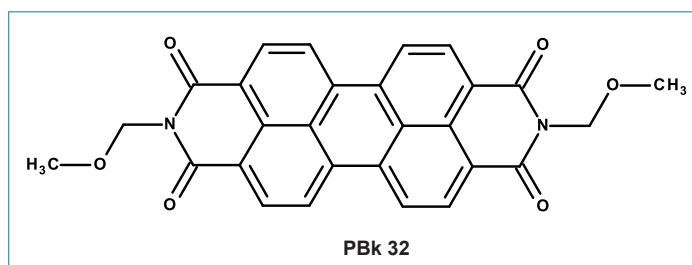


TABLE 1—Predicted TSR Value for Gray Coatings Made with NIR-Reflective Black Pigment^a

GRAY COATING L VALUE	PREDICTED TSR OVER WHITE SUBSTRATE (%)	PREDICTED TSR OVER BLACK SUBSTRATE (%)	RATIO OF TiO ₂ TO NIR-REFLECTING BLACK
97	86.0	79.6	100/0
55	41.1	38.6	77/23
45	33.5	31.7	55/45
35	27.8	26.6	25/75
28	24.7	23.7	0/100

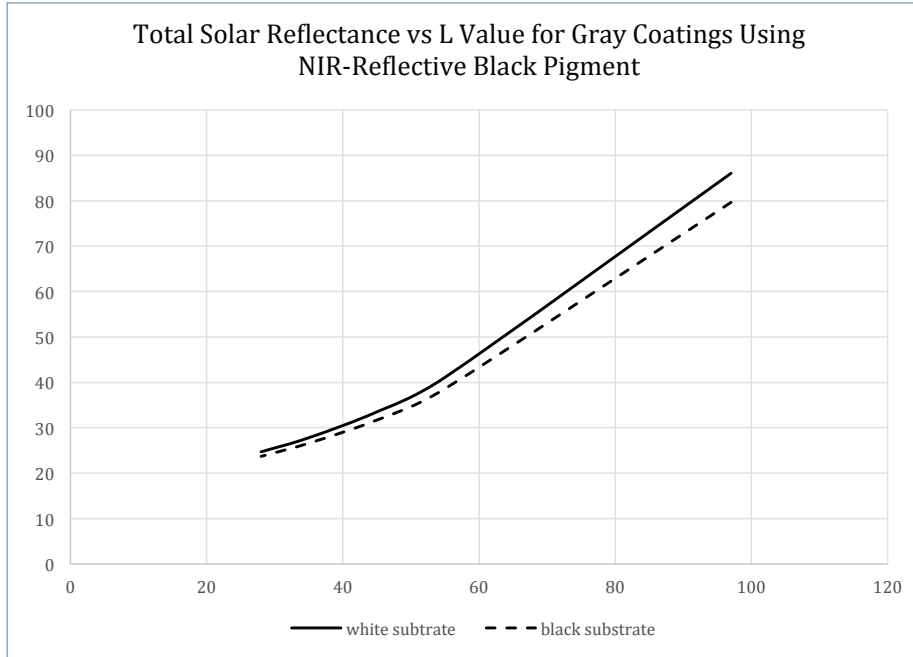
(a) The table shows that the substrate effect is minimal when using NIR-reflective pigments.

TABLE 2—Predicted TSR Value for Gray Coatings Made with NIR-Transparent Black Pigment^a

GRAY COATING L VALUE	PREDICTED TSR OVER WHITE SUBSTRATE (%)	PREDICTED TSR OVER BLACK SUBSTRATE (%)	RATIO OF TiO ₂ TO NIR-TRANSPARENT BLACK (PIGMENT BLACK 32)
97	86.0	79.6	100/0
55	51.6	31.3	90.5/9.5
45	47.2	26.6	79.5/20.5
35	43.1	21.1	55/45
25	38.8	10.6	0/100

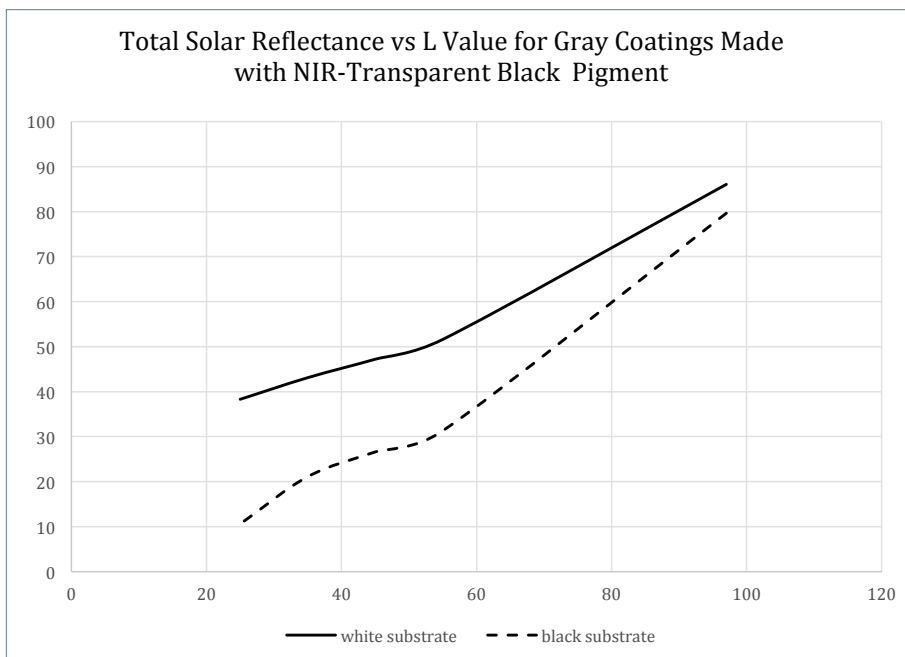
(a) The table shows the effect the substrate can have on the predicted TSR values when NIR-transparent pigments are used to make a gray coating.

FIGURE 3—Substrate influence for an NIR-reflective coating.^a



(a) Plotting the predicted TSR value over white and black substrates vs the L value of the gray coatings shows that the substrate influence is minimal when using NIR-reflective functional black pigments.

FIGURE 4—Substrate influence for an NIR-transparent coating.^a



(a) As the L value decreases, the influence of the substrate on TSR results is more pronounced when NIR-transparent functional black pigments are used to make gray coatings.

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TABLE 3—Predicted and Measured TSR Values over White Vinyl Substrate^a

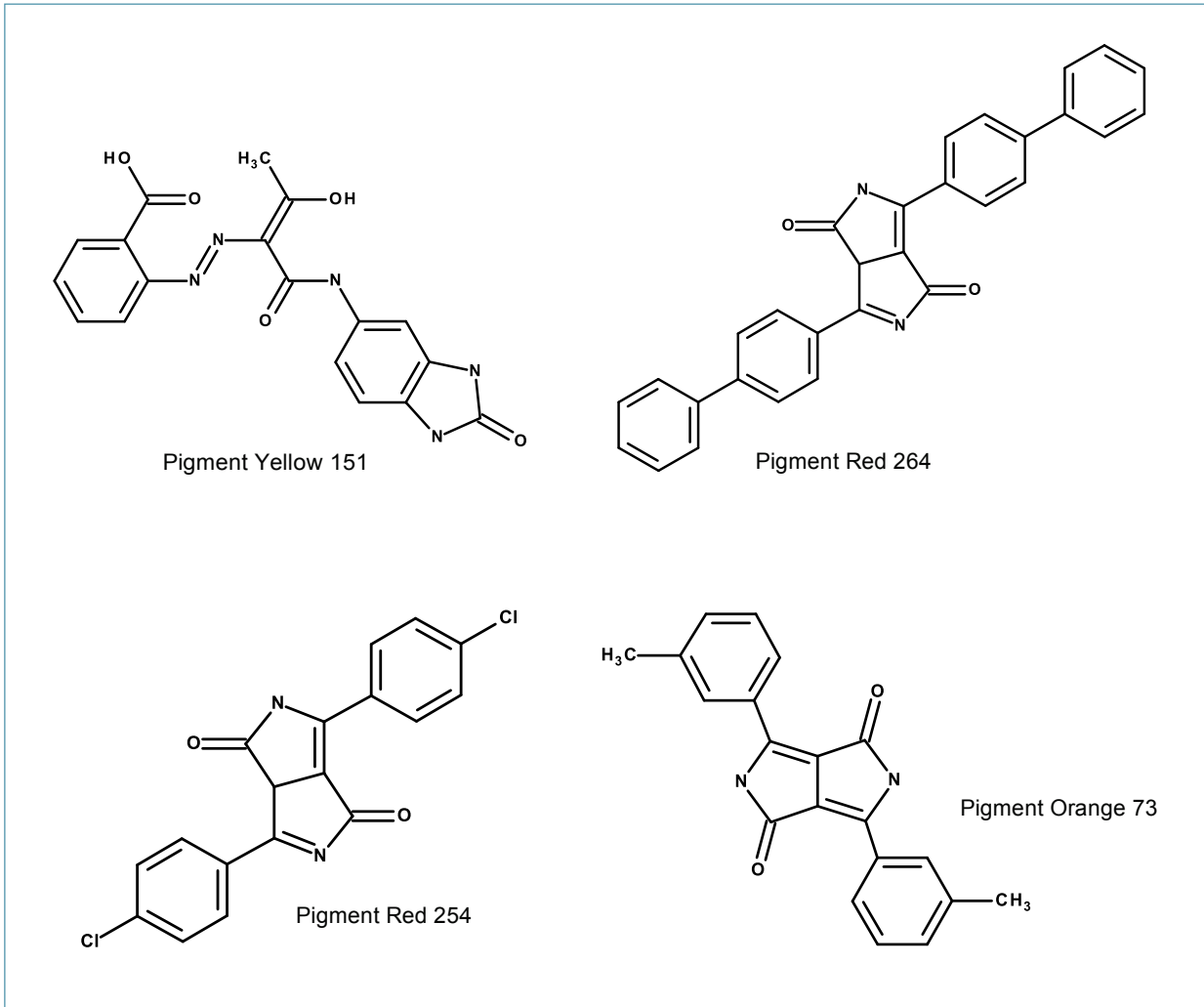
PIGMENT COMPOSITION	NIR -TRANSPARENT PIGMENTS (%)	NIR-REFLECTIVE PIGMENTS (%)	CONVENTIONAL PIGMENTS (%)
PIGMENT BLACK 32 PERYLENE BLACK	13.9	—	—
PIGMENT BROWN 29 IRON CHROMIUM (III) OXIDE	—	65.9	—
PIGMENT BLACK 7 CARBON BLACK	—	—	7.5
PIGMENT WHITE 6 TITANIUM DIOXIDE	—	—	17.2
PIGMENT YELLOW 151 BENZIMIDAZOLONE	65.8	12.4	—
PIGMENT RED 264 DPP RUBINE	20.4	—	—
PIGMENT RED 254 DPP RED	—	21.6	9.9
PIGMENT ORANGE 73 DPP ORANGE	—	—	65.4
PREDICTED TSR VALUE	43.8	33.3	5.6
MEASURED TSR VALUE	43.6	27.8	6.4

(a) The data shows that the highest TSR value over white vinyl substrates are obtained when using NIR-transparent functional black pigments.

TABLE 4—Predicted and Actual TSR and Measured HBU Values over Bare Steel and White Primed Steel

PIGMENT COMPOSITION	NIR-TRANSPARENT PIGMENTS OVER WHITE PRIMED STEEL	NIR-TRANSPARENT PIGMENTS OVER BARE STEEL	NIR-REFLECTIVE PIGMENTS OVER BARE STEEL	CONVENTIONAL PIGMENTS OVER BARE STEEL
PIGMENT BLACK 32 PERYLENE BLACK	73.0%	73.0%	55.8%	—
PIGMENT BROWN 29 IRON CHROMIUM (III) OXIDE	—	—	43.0%	—
PIGMENT BLACK 7 CARBON BLACK	—	—	—	36.5%
PIGMENT WHITE 6 TITANIUM DIOXIDE	27.0%	27.0%	1.2%	—
PIGMENT YELLOW 42 YELLOW IRON OXIDE	—	—	—	63.5%
PREDICTED TSR VALUE	41.7%	27.0%	22.3%	4.3%
MEASURED TSR VALUE	37.8%	19.2%	21.7%	4.9%
MEASURED HBU	15.2°C	27.1°C	22.8°C	32.3°C

FIGURE 5—Structures of organic pigments.^a



(a) The figure illustrates the structure of the organic pigments used in addition to functional black pigments to match RAL 8017 in this example.