

IRON OXIDE PIGMENTS

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Natural iron oxides are derived from hematite, which is a red iron oxide mineral; limonites, which vary from yellow to brown, such as ochers, siennas, and umbers; and magnetite, which is black iron oxide. Synthetic iron oxide pigments are produced from basic chemicals. The three major methods for the manufacture of synthetic iron oxides are thermal decomposition of iron salts or iron compounds, precipitation of iron salts usually accompanied by oxidation, and reduction of organic compounds by iron (Podolsky and Keller, 1994, p. 765, 772).

Production

U.S. output of finished natural (mined) iron oxide pigments (IOPs) sold by processors in 2000 was 87,800 metric tons (t), about 5% less than in 1999; this category accounted for 51% of the tonnage and 15% of the value of total IOP output. Finished synthetic IOPs were 83,900 t, a decrease of 8% from that of 1999, and accounted for 49% of the tonnage and 85% of the value of total IOP output. Total finished natural and synthetic IOPs were 172,000 t, about 6% less than in 1999 (table 2).

Production data for crude IOPs sold or used were developed from a voluntary survey. Of six known companies, data were obtained from five, for an 83% response rate. By tonnage, the five companies represented about 70% of the output. In a second voluntary survey, data were received from 12 of 14 known operations that produced finished IOPs, for a response rate of 86%. By tonnage, the 12 operations represented 80% of the output.

Data were obtained from three producers of regenerator iron oxide, which is obtained when spent pickle liquor from steelmaking is treated (table 3). Output from the three companies was about 34,500 t of iron oxide. A major end use for this material was ferrites. Regenerator iron oxide data are

not included in tables 1, 2, and 4.

Bayer Corp. introduced two new yellow grades of synthetic IOPs, which were geared toward use in standard solvent-based paints and coatings, as well as high solids and water-based paints. One of the pigments was being manufactured at the company's new iron oxide unit at New Martinsville, WV, and the other yellow pigment was being made at Bayer's facility near Sao Paulo, Brazil, specifically for sale in North American markets (Bayer Corp., October 23, 2000, Bayer Corp. introduces two new yellow grades of synthetic iron oxide pigments for use in architectural paints and coatings, accessed June 21, 2001, at URL <http://www.bayerus.com/new/2000/10.23.00.html>).

Laporte plc announced its intention to sell its pigments and additives companies to K-L Holdings Inc., a company established by Kohlberg Kravis Roberts & Co., L.P. Laporte's Pigments Division comprised IOP companies in the United States and Europe. Markets included construction, coatings, and specialty applications (Industrial Minerals, 2000).

Consumption

The largest end-use categories for total U.S. IOP output (natural and synthetic) in 2000 continued to be construction with 32% and coatings with 22% (table 4).

In New Jersey, a noise barrier concrete wall was installed along a 26-kilometer corridor on interstate highways. Coloring for the entire wall system was a brownish gray (taupe) supplied by Bayer Corp. and was similar to the color of tree trunks surrounding the noise barrier. Changes in reflective light and the varying textures of the wall gave the appearance of three different colors being used (Bayer Corp., May 9, 2000, Color concrete noise barrier walls enhance landscapes along U.S.

Iron Oxide Pigments in the 20th Century

In 1900, U.S. output of natural (mined) iron oxide pigments (IOPs), including ocher, sienna, umber, and "metallic paint" was about 39,000 metric tons with a value of \$490,000. "Metallic paint" was red and brown iron oxides produced by grinding the impure mineral in the natural state. Imports of ocher, sienna, and umber were about 5,000 tons. Other major producing countries of ocher were France with 33,100 tons, the United Kingdom with 15,400 tons, and the German Empire with 11,500 tons. In the early 1900s in the United States, natural IOPs were used mostly in linoleum and ready-mixed paints. The other category of IOPs, synthetic, is made by a chemical process, such as the Penniman-Zoph precipitation process, which became commercially important around the 1930s. During World War II, many IOP producers

geared their operations more closely to war needs such as olive drab and camouflage paints for military vehicles, artillery, and aircraft. Paint for shipbuilding required large quantities of both natural and synthetic red iron oxide. After the war ended, peace time uses resumed, such as farm buildings, box cars, and domestic construction.

In 2000, total U.S. output of finished IOPs (natural and synthetic) was 172,000 tons with a value of \$171 million. The largest end-use categories for total IOP output were construction (such as cement, mortar, and concrete) and paints and coatings. Total U.S. imports of IOPs (natural and synthetic) were 91,300 tons, with China supplying about 48,000 tons, or 53 %, most of which was synthetic material.

interstates, accessed June 21, 2001, at URL <http://www.bayerus.com/new/2000/05.10.00html>).

Concrete roof tile has made a major appearance throughout the United States during the past 15 to 20 years. Concrete tile roofs initially were found only in the sunbelt areas of Arizona, California, southern Florida, and Nevada because of the strong Spanish and Mediterranean influences. Newer styles have been developed, along with improved installation procedures, and concrete roof tiles have spread to colder areas, including Colorado, Minnesota, Montana, and Utah. Styles available from at least one supplier include flat tile that simulates wood shakes or shingles and smooth slate. Color for the tiles is from numerous shades of black, red, and yellow IOPs. Two or more of these shades are blended to create a wide selection of earth-tone colors, including shades of adobe, buff, and tan. Concrete roof tile strengthens over time; in Europe, where concrete roof tile has been the predominant roofing material for nearly a century, roof tiles can last over 75 years, even in severe weather conditions. The tiles are also fire resistant, and technological advances have enabled the tile to rival the appearance of clay tile (Bayer Corp., October 17, 2000, Colorful concrete roof tile enhances the quality and style of homes throughout the United States, accessed June 21, 2001, at URL <http://www.bayerus.com/new/2000/10.17.00.html>).

IOPs, especially those with large particle size that maximizes opacity and gives high color strength, have been manufactured since the late 19th century. In the past 40 years, synthetically produced transparent iron oxides have been developed that give and enhance color and protect wood against weathering, fungi, and ultraviolet radiation. The preferred processes for the manufacture of transparent iron oxide involve precipitation and oxidation of iron from a ferrous salt solution. Ferrous sulfate is the preferred salt because it is readily available as a byproduct from the manufacture of titanium dioxide pigment or from the steel pickling industry. In wood stains and furniture finishes, transparent IOPs find applications such as fencing, decks, lawn furniture, siding, cabinetry, and flooring (Wright and McKenna, 2000).

Prices

Yearend 2000 prices, meant to serve as a general guideline, converted to dollars per kilogram, in bags, per truckload, free on board (f.o.b.) warehouse, were synthetic black, \$1.85 to \$1.96; synthetic brown, \$1.83 to \$1.94; natural red, \$0.65 to \$1.10; natural ochre, \$0.81; and synthetic yellow, \$1.80 to \$1.94 (Chemical Market Reporter, 2000). These prices were essentially unchanged from those of 1999.

The average annual Producer Price Index (PPI) for IOPs for 2000 was 174.9, compared with 173.0 in 1999. The PPI measures the average change over time in the selling prices received by domestic producers of IOPs. The base year for the IOP PPI is June 1983 (Bureau of Labor Statistics, June 20, 2001, Producer price index revision—Current series, accessed June 28, 2001, at URL <http://stats.bls.gov/sahome.html>).

Foreign Trade

U.S. exports of pigment grade IOPs in 2000 were 9,640 t, 30% less than those of 1999 (table 5). The largest recipients were Japan (22%), Mexico (22%), and Germany (15%). In 2000, U.S. imports of natural IOPs were 7,340 t (tables 6,

7). The 718 t of micaceous iron oxide (MIO) from Belgium and 913 t from the Netherlands in 2000, however, may not belong in this table, because those countries are not known to be suppliers of MIO. This has yet to be verified with the U.S. Census Bureau; if verified, U.S. imports of MIO would drop to 588 t with a value of \$463,000. Imports of synthetic IOPs were 84,000 t, 8% higher than those of 1999. The largest amounts of material were supplied by China (57%), Germany (19%), and India (5%). The total value of synthetic IOPs imports was \$73.3 million, which was an increase of 6% compared with imports in 1999.

Total U.S. imports of IOPs (natural and synthetic) were 91,300 t, 7% more than in 1999. The total value of the imports was \$76.7 million, 5% higher than that of 1999 (tables 6, 7).

Outlook

Consumption of IOPs is related to activity in the automotive, construction, and housing industries. U.S. apparent consumption of IOPs in 2000 (calculated as production plus imports minus exports) was about 254,000 t, about the same as in 1999. Although housing starts in 2000 were estimated to be about 4% fewer than in 1999, growth in IOP demand reportedly has exceeded overall construction market growth because of an increasing preference for concrete products. An example is the roof tile segment of the industry. One area of the paint industry that has shown above average growth is that of architectural coatings. Use of IOPs as a colorant in plastics reportedly has been spurred in part by plastics continually replacing metal and glass in products such as automobiles (Chemical Products Synopsis, 2000).

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TABLE 1
SALIENT U.S. IRON OXIDE PIGMENTS STATISTICS 1/

(Metric tons, unless otherwise noted)

	1996	1997	1998	1999	2000
Crude pigments sold or used 2/	44,700	46,900	46,100	44,100	57,100
Value thousands	\$6,990	\$7,580	\$7,290	\$7,740	\$4,470
Finished pigments sold 3/	163,000	176,000	180,000	183,000 r/	172,000
Value thousands	\$183,000	\$193,000	\$193,000	\$187,000 r/	\$171,000
Exports	16,000	16,600	14,600	13,800	9,640
Value thousands	\$23,200	\$20,600	\$18,200	\$15,200	\$17,200
Imports for consumption	59,600	68,200	67,500	85,100	91,300
Value thousands	\$72,800	\$75,400	\$64,200	\$73,000	\$76,700

r/ Revised.

1/ Data are rounded to no more than three significant digits.

2/ Mined.

3/ Natural (mined) and synthetic.

TABLE 2
FINISHED IRON OXIDE PIGMENTS SOLD BY PROCESSORS IN THE UNITED STATES, BY KIND 1/

Kind	1999		2000	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Natural:				
Black; magnetite	21,000	\$3,690	19,400	\$3,190
Umbers:				
Burnt	2,440	3,280	2,100	2,880
Raw	W	W	W	W
Red, iron oxide 2/	55,700	11,800	52,700	10,600
Undistributed and other 3/	12,900	8,590	13,600	8,550
Total	92,000	27,300	87,800	25,200
Synthetic:				
Black, iron oxide	24,700 r/	40,600 r/	22,400	35,800
Brown, iron oxide	(4/) r/	(4/) r/	7,570	13,800
Red, iron oxide	(4/) r/	(4/) r/	53,900	95,800
Yellow, iron oxide	22,700 r/	40,300 r/	(5/)	(5/)
Mixtures of natural and synthetic; iron oxides	(4/) r/	(4/) r/	(6/)	(6/)
Other; specialty oxides	(4/) r/	(4/) r/	--	--
Undistributed	43,800 r/ 7/	79,200 r/ 7/	--	--
Total	91,200 r/	160,000 r/	83,900	145,000
Grand total	183,000 r/	187,000 r/	172,000	171,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Undistributed and other." -- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Includes pyrite cinder.

3/ Includes raw umber, burnt sienna, ochre and raw sienna.

4/ Included with "Undistributed" to avoid disclosing company proprietary data.

5/ Included with "Red, iron oxide" to avoid disclosing company proprietary data.

6/ Included with "Brown, iron oxide" to avoid disclosing company proprietary data.

7/ Includes brown iron oxide, red iron oxide, mixtures of natural and synthetic iron oxide and other specialty oxides.

TABLE 3
PRODUCERS OF IRON OXIDE PIGMENTS, REGENERATOR IRON OXIDES,
AND STEEL PLANT WASTE IRON OXIDES IN THE UNITED STATES IN 2000

Producers	Plant location
Finished pigments:	
Alabama Pigments Co.	Green Pond, AL.
Arizona Oxides L.L.C.	El Mirage, AZ.
Bayer Corp.	New Martinsville, WV.
Dynamic Color Solutions, Inc.	Milwaukee, WI.
Elementis Pigments Inc.	Emeryville, CA; East St. Louis, IL; Easton, PA.
Hoover Color Corp.	Hiwassee, VA.

TABLE 3--Continued
PRODUCERS OF IRON OXIDE PIGMENTS, REGENERATOR IRON OXIDES,
AND STEEL PLANT WASTE IRON OXIDES IN THE UNITED STATES IN 2000

Producers	Plant location
Finished pigments--Continued:	
Hoover Color Corp.	Hiwassee, VA.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Pea Ridge Iron Ore Co.	Sullivan, MO.
Prince Manufacturing Co., Inc.	Quincy, IL and Bowmanstown, PA.
Rockwood Pigments Inc.	Beltsville, MD and St. Louis, MO.
Solomon Grind-Chem Services Inc.	Springfield, IL.
Crude pigments:	
Alabama Pigments Co.	Green Pond, AL.
Arizona Oxides L.L.C.	El Mirage, AZ.
Cleveland-Cliffs Iron Co., Mather Mine and Pioneer plant (closed July 31, 1979; shipping from stockpile.)	Negaunee, MI.
Hoover Color Corp.	Hiwassee, VA.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Pea Ridge Iron Ore Co.	Sullivan, MO.
Regenerator and steel plant waste iron oxides:	
Bailey-PVS Oxides, L.L.C.	Fairfield, AL.
International Steel Services, Inc.	Allenport, PA.
Weirton Steel Corp.	Weirton, WV.

TABLE 4
ESTIMATED IRON OXIDE PIGMENT CONSUMPTION, BY END USE, AS A PERCENTAGE OF REPORTED SHIPMENTS

End use	All iron oxides		Natural iron oxides		Synthetic iron oxides	
	1999 r/ 2000	1999	2000	1999	2000	1999
Coatings (industrial finishes and trade sales coatings: lacquers, paints, varnishes)	22	22	15	12	29 r/	31
Construction materials (cement, mortar, preformed concrete, roofing granules)	30	32	20	23	W	W
Colorants for ceramics, glass, paper, plastics, rubber, textiles	10	10	W	W	11	10
Foundry sands	8	W	15	W	--	--
Industrial chemicals (such as catalysts)	8	8	W	W	W	W
Other 1/	22	28	50 r/	65	60 r/	59
Total	100	100	100	100	100	100

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." -- Zero.

1/ Includes animal feed, cosmetics, ferrites, fertilizers, magnetic ink and toner, polishing agents and data indicated by the symbol W.

TABLE 5
U.S. EXPORTS OF IRON OXIDES AND HYDROXIDES, BY COUNTRY 1/

Country	1999				2000			
	Pigment grade		Other grade		Pigment grade		Other grade	
	Quantity (metric tons)	Value (thousands)						
Argentina	68	\$279	106	\$57	4	\$14	79	\$21
Australia	90	204	297	703	153	301	305	732
Belgium	86	672	90	417	5	29	33	128
Brazil	17	54	248	603	48	28	255	465
Canada	41	51	11,000	13,500	38	42	10,600	12,100
China	223	798	39	88	84	156	452	143
Colombia	33	57	63	69	51	205	89	103
France	35	81	278	1,450	9	29	210	679
Germany	976	1,430	767	4,840	1,450	1,920	2,280	4,510
Hong Kong	11	30	1,600	4,780	529	288	1,310	3,290
India	476	759	314	387	281	382	491	622
Indonesia	10	31	167	246	15	32	219	291
Italy	18	51	144	367	--	--	909	808

See footnotes at end of table.

TABLE 5--Continued
U.S. EXPORTS OF IRON OXIDES AND HYDROXIDES, BY COUNTRY 1/

Country	1999				2000			
	Pigment grade		Other grade		Pigment grade		Other grade	
	Quantity (metric tons)	Value (thousands)						
Japan	1,710	\$2,200	3,690	\$9,360	2,160	\$3,860	3,610	\$7,160
Korea, Republic of	327	484	2,860	10,500	467	727	1,210	3,480
Malaysia	--	--	27	22	--	--	338	1,060
Mexico	7,740	3,450	3,210	3,740	2,100	2,060	2,560	2,340
Netherlands	146	394	897	1,440	--	--	792	1,290
Russia	105	370	20	80	508	755	16	44
Singapore	16	41	118	228	38	224	160	294
South Africa	294	401	1	5	1	3	3	5
Taiwan	60	113	1,120	908	204	1,070	1,340	1,320
Thailand	41	141	500	2,130	127	121	292	266
Turkey	--	--	19	51	3	16	--	--
United Kingdom	821	2,400	2,080	3,150	1,150	4,520	2,800	4,620
Venezuela	13	45	23	134	3	13	105	35
Other	423	665	378	639	221	421	435	758
Total	13,800	15,200	30,100	59,800	9,640	17,200	30,900	46,500

-- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF SELECTED IRON OXIDE PIGMENTS, BY TYPE 1/

Type	1999		2000		Principal sources, 2000 (metric tons)
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)	
Natural:					
Earth colors 3/	4,680	\$2,020	5,120	\$2,240	Cyprus, 3,850; Spain, 781; Germany, 345; India, 125; South Africa, 21; United Kingdom, 3; Italy, 1; Japan, (4).
Micaceous	2,770	1,690	2,220	1,170	Netherlands, 913; Belgium, 718; Australia, 196; Austria, 151; France, 91; China, 80; Morocco, 48; Mexico, 20; Italy, 2; Germany, (4).
Total	7,450	3,710	7,340	3,410	
Synthetic:					
Black	12,000	15,800	16,000	22,500	China, 4,580; India, 4,160; Germany, 3,920; Japan, 892; Mexico, 829; Italy, 744; Hong Kong, 376; Netherlands, 230; United Kingdom, 110; Canada, 84; Belgium, 45.
Red	35,000	25,700	36,300	25,500	China, 23,900; Germany, 6,570; Canada, 1,540; Hong Kong, 862; Netherlands, 708; Italy, 520; Mexico, 471; India, 339; Spain, 335; Japan, 273; United Kingdom, 261; Brazil, 152; Colombia, 114; New Caledonia, 100; Sweden, 72; Czech Republic, 36; France, 32; Belgium, 1.
Yellow	28,600	24,700	30,000	22,600	China, 19,400; Germany, 4,640; Brazil, 2,870; Mexico, 1,470; Hong Kong, 612; Italy, 398; Spain, 141; United Kingdom, 130; Canada, 121; Colombia, 58; Ukraine, 41; Belgium, 36; Hungary, 34; Japan, 21; France, 19; Republic of Korea, 17; Switzerland, 1.
Other 5/	1,960	3,110	1,780	2,630	Germany, 1,030; Canada, 470; China, 181; Mexico, 24; Italy, 20; India, 20; Poland, 19; United Kingdom, 7; Belgium, 3; Japan, 3.
Total	77,600	69,300	84,000	73,300	
Grand total	85,100	73,000	91,300	76,700	

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Customs value.

3/ Includes those earth colors not elsewhere specified or included.

4/ Less than 1/2 unit.

5/ Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF IRON OXIDE AND IRON HYDROXIDE PIGMENTS, BY COUNTRY 1/

Country	Natural				Synthetic			
	1999 Quantity (metric tons)	1999 Value 2/ (thousands)	2000 Quantity (metric tons)	2000 Value 2/ (thousands)	1999 Quantity (metric tons)	1999 Value 2/ (thousands)	2000 Quantity (metric tons)	2000 Value 2/ (thousands)
Austria	227	\$249	151	\$146	--	--	--	--
Belgium	--	--	718	303	49	\$321	86	\$396
Brazil	--	--	--	--	2,270	2,170	3,020	2,890
Canada	18	3	--	--	4,060	1,960	2,210	1,750
China	20	18	80	36	40,000	21,700	48,000	25,500
Colombia	67	112	--	--	124	155	172	228
Cyprus	3,820	1,280	3,850	1,510	--	--	--	--
France	292	225	91	73	74	711	51	516
Germany	278	364	345	474	17,200	22,800	16,100	18,700
Hong Kong	--	--	--	--	586	370	1,850	1,320
India	147	34	125	29	3,330	2,240	4,520	3,180
Italy	--	--	2	12	2,810	2,920	1,680	2,030
Japan	(3/)	2	(3/)	3	1,450	7,670	1,190	11,200
Mexico	21	4	20	3	2,540	2,290	2,790	2,470
Netherlands	2,220	1,190	913	407	173	87	938	346
Spain	160	59	781	180	530	437	476	304
Sweden	--	--	--	--	1,150	307	72	22
United Kingdom	(3/)	6	3	22	1,010	2,880	509	2,160
Other	189	159	265	217	197	299	247	252
Total	7,450	3,710	7,340	3,410	77,600	69,300	84,000	73,300

-- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Customs value.

3/ Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 8
NATURAL IRON OXIDE PIGMENTS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1996	1997	1998	1999	2000 e/
Austria e/	7,500	7,500	7,000	7,000	7,000
Brazil e/	5,500	5,500	5,500	5,500	5,500
Chile	18,821	10,678	10,449	10,500 e/	10,600
Cyprus (umber)	4,604	7,120 r/	6,056 r/	9,169 r/	12,258 4/
France e/	1,000	1,000	1,000	1,000	1,000
Germany 5/	3,754	4,176	4,000 e/	4,000 e/	4,000
India (ocher)	284,546	347,429	351,704	360,000 e/	365,000 4/
Iran	2,500 e/	10,000 r/	13,300 r/	13,300 r/	13,500 4/
Italy e/	500	500	500	500	500
Pakistan (ocher) e/	6,100	2,600	3,180 4/	3,200	4,700
Paraguay (ocher) e/	300	300	300	300	300
South Africa	643	284	186	216	569 4/
Spain: e/					
Ocher	7,000	7,000	7,000	7,000	7,000
Red iron oxide	15,000	15,000	15,000	15,000	15,000
United States	44,700 r/	46,900 r/	46,100 r/	44,100 r/	57,100 4/
Zimbabwe e/	400	--	--	--	--

e/ Estimated. r/ Revised. -- Zero.

1/ Estimated data are rounded to no more than three significant digits.

2/ Table includes data available through June 4, 2001.

3/ In addition to the countries listed, a number of others undoubtedly produce iron oxide pigments, but output is not reported and no basis is available for formulating estimates of output levels. Such countries include, but are not limited to, Azerbaijan, China, Kazakhstan, Russia, and Ukraine. Unreported output is probably substantial.

4/ Reported figure.

5/ Includes Vandyke brown.