



2015 Minerals Yearbook

IRON OXIDE PIGMENTS [ADVANCE RELEASE]

IRON OXIDE PIGMENTS

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In 2015, natural crude iron oxide pigment (IOP) production in the United States was virtually unchanged compared with that of 2014, but actual U.S. production data are withheld to avoid disclosing company proprietary data. Finished natural and synthetic IOPs sold by processors increased by 18% to 53,500 metric tons (t) valued at \$77.9 million in 2015 from 45,300 t valued at \$71.5 million in 2014 (table 1). Exports of pigment-grade iron oxides increased slightly to 8,930 t valued at \$17.2 million in 2015 compared with 8,790 t valued at \$16 million in 2014. Imports of natural and synthetic IOPs combined increased slightly to 176,000 t valued at \$209 million in 2015 compared with 175,000 t valued at \$208 million in 2014 (tables 1, 4, 5).

Natural IOPs are inorganic compounds that are suitable for use as pigments after milling and minimal processing. They commonly are the preferred choice of the natural minerals for pigmentation because they are low cost, inherently color stable, and nontoxic. Typically, they are derived from hematite (Fe_2O_3), which is a red iron oxide mineral; goethite or limonite (Fe-OH), minerals that vary from yellow to brown, which include ochers and siennas (yellow) and umbers (brown); and magnetite (Fe_3O_4), a black iron oxide mineral. A wider variety of colors can be produced from natural IOPs by blending various IOPs or by calcination of hydrated natural IOPs.

Synthetic IOPs are widely used as colorants and compete with natural IOPs in many color applications, in part because colors can be more precisely duplicated and a substantially wider variety of colors can be produced. They are manufactured using the following three methods: precipitation of iron salts, usually accompanied by oxidation; reduction of organic compounds by iron; and thermal decomposition of iron salts or iron compounds. Organic colorants can be used for some applications, but they tend to fade over time from exposure to sunlight.

Production

Domestic production data for natural crude IOPs were derived from voluntary responses to a U.S. Geological Survey (USGS) canvass of three domestic producers. U.S. production data for crude (natural) IOPs sold or used in 2015 were developed using reported data from two companies and estimates for the nonrespondent. These data are withheld from publication to avoid disclosing company proprietary data. Estimated production was virtually unchanged in 2015 compared with that of 2014.

In a second voluntary USGS survey, sales data for finished (natural and synthetic) IOPs were received from 7 of 11 known processing operations, representing more than 90% of the tonnage shown in table 1. Data for the nonrespondents were

estimated on the basis of prior-year sales levels, employment hours, and industry trends. Sales of finished pigments were 53,500 t in 2015, up by 18% from 45,300 t in 2014. Sales data for finished IOPs were collected only from operations that process material, such as the crushing and grinding of natural IOPs, or that make synthetic IOPs, not operations that simply blend, mix, repackage, and (or) resell IOP material.

At least four U.S. companies, operating nine plants, produced regenerated iron oxide during steelmaking (table 2). Iron oxide is obtained during steelmaking when steel is treated with hydrochloric acid to remove surface oxides. Iron oxide is separated from the spent pickle liquor when it is treated to recycle the acid and reduce waste. Regenerated iron oxide data were not included in table 1 because the iron oxides are not natural (mined) or synthetic (manufactured) and must undergo additional processing before being suitable for use in typical IOP applications.

Applied Minerals, Inc.'s Dragon Mine property in Utah contains high-purity iron oxide consisting of hematite, goethite, and limonite along with halloysite clay; the total measured iron oxide resource was 3.3 million metric tons (Applied Minerals, Inc., 2015a, b). Applied Minerals began production of its iron oxide product toward the end of 2014 at its 40,000-metric-ton-per-year (t/yr) processing plant (Patel, 2015). In 2015, near yearend, Applied Minerals entered into separate contracts with two specialty chemical materials distributors to sell its AMIRON™ technical-grade iron oxides products and its DRAGONITE™ halloysite clay. Brandt Technologies, LLC will sell Applied Minerals' products primarily to States in the Midwest region of the United States, and E.T. Horn Co. will sell Applied Minerals' products in Arkansas, Louisiana, Oklahoma, Texas, and the Western United States (Applied Minerals, Inc., 2015c; BusinessWire, 2015). Applied Minerals promoted its transparent IOP products to the woodstains market, as additives to foundry sands, and as a desulfurization catalyst to the energy and biogas industries as a cost-effective scavenger of highly corrosive hydrogen sulfide gas, a byproduct of the anaerobic conversion of biomass (Applied Minerals, Inc., 2015d). Applied Minerals was pursuing opportunities with domestic companies that had traditionally been dependent on imported IOP products from Asia as well as IOP customers in Asia and Europe (Applied Minerals, Inc., 2015a, b; Patel, 2015).

Texas-based Huntsman Corp., a global specialty chemical company, continued with construction of its new \$172 million synthetic IOP production plant, near Augusta, GA, previously owned by Rockwood Pigments NA, Inc. Production of black, red, and yellow synthetic IOPs was expected to begin at the 30,000-t/yr advanced technology facility in the first half of 2016. Completion of the plant, the first new synthetic IOP production plant built in the United States in nearly 35 years,

¹Deceased.

had been delayed by adverse weather conditions, a change in engineering firms, and the transition in ownership from Rockwood Pigments. Huntsman Corp. expected to begin to close its existing plants in Cartersville, GA, East St. Louis, IL, and King of Prussia, PA, and part of its Beltsville, MD, facility during the next several years and produce IOPs primarily from the new facility in Georgia (Huntsman International LLC, 2015; Rausch, 2015).

Consumption

End-use data for IOPs are not surveyed by the USGS or other organizations, although the increase in production of finished IOPs and a 10% increase in domestic housing starts and completions suggest a similarly significant increase in IOP consumption (U.S. Census Bureau, 2016). In 2015, of the 53,500 t of finished natural and synthetic IOPs that were produced, an estimated 35% of sales was for use in concrete and other construction products, 30% in paints and coatings, 15% for foundry sands and other foundry uses, 5% in industrial chemicals, 5% in animal foods, 2% in glass and ceramics, and the remainder in other uses.

IOPs were used in construction materials, including concrete products such as block, brick, or segmental retaining wall units; decorative concrete; mortar; paving stones; precast products of various sizes or dimensions; ready-mixed concrete; and roofing tiles. Tinted concrete is often stamped to resemble brick, slate, stone, and many more shapes and forms found in nature, including wood (Pinto, 2008, p. 4, 6).

The second-ranked market for IOPs was as a tint in paints and coatings. Other end uses included colorants for ceramics, glass, paper, plastics, rubber, and textiles; in animal feed; in cosmetics; in fertilizers; in other-than-colorant uses in ferrites; in foundry sands; in industrial chemicals, such as catalysts; and in magnetic ink and toner.

A major end use for regenerator iron oxides was in ferrite ceramic magnets. Two types of ferrites are used—hard, which retain magnetism permanently, and soft, which do not. Hard ferrites are used in flexible magnets, generators, loudspeakers, and motors. Soft ferrites are used in computers, cores for radio frequency coils, microwave communication systems, microwave ferrites for telecommunications, and other industrial applications. Other end uses for regenerator iron oxides include color pigments in construction materials, cosmetic preparations, dyes and paints, and plastic products.

Prices

The annual average producer price index (PPI) for IOPs (U.S. Bureau of Labor Statistics Series ID WPU06220206) was 238.3 in 2015 compared with 234.6 in 2014. The PPI was virtually unchanged throughout 2015 at 238.3, only decreasing to 238.2 from October through December. The PPI measured the average change in the selling prices charged by domestic producers of IOPs over time (U.S. Bureau of Labor Statistics, 2016). Unit values for finished natural and synthetic IOPs reported by domestic producers ranged from \$0.45 to \$4.24 per kilogram, with an average unit value of \$1.46 per kilogram.

Foreign Trade

In 2015, U.S. exports of pigment-grade and other iron oxides and hydroxides combined decreased by about 3%. IOPs were mainly exported to China, 59%; Spain, 12%; Mexico, 11%; and Canada, 7% (table 3).

U.S. exports of pigment-grade iron oxides increased slightly to 8,930 t valued at \$17.2 million in 2015, and the unit value increased by 5.5%. Mexico was the leading destination, accounting for 49% of pigment-grade exports, China was second with 22%, and Belgium was third with 10% (tables 1, 3). Exports of other grades of iron oxides and hydroxides decreased by about 4% to 58,200 t in 2015 with a total value of \$32.7 million; the unit value increased by 5%. China, Spain, Canada, and Mexico were, in descending order, the major destinations for export of other grades of IOPs and hydroxides, accounting for 65%, 14%, 8%, and 5% of the export tonnage, respectively (table 3).

U.S. imports of all IOPs and hydroxides increased slightly to nearly 176,000 t in 2015 from those of 2014, and were about 66% higher than the recent low of 106,000 in 2009 (tables 1, 4).

Imports of natural IOPs increased slightly. The leading source was Cyprus, with 61% of the tonnage, followed by France with 16% and Austria with 13%. Imports of synthetic IOPs increased slightly but were virtually unchanged. The leading sources of synthetic IOP imports were China with 52% of the tonnage; Germany, 27%; Brazil, 7%; Canada, 6%; and Italy, 5% (table 5).

World Review

Natural IOPs were produced in at least nine countries in 2015 (table 6). Several other countries were thought to produce IOPs, but output, which may have been substantial, was not reported, and no basis was available for estimating output levels. Because many of Europe's IOP producers supplied external markets, they were not expected to be affected significantly by sluggish European construction markets. In general, IOP companies with a global customer base were less vulnerable to regional economic fluctuations. Consumption of pigment minerals was expanding significantly for certain emerging markets, especially those of China, India, and Thailand.

Austria.—In 2015, Kärntner Montanindustrie GmbH continued production of micaceous iron oxide (MIO) from its underground mine in Waldenstein, from which it exported about 95% of its MIO products to the global market. It exported its products to as many as 80 countries (Kärntner Montanindustrie GmbH, 2016, p. 12). MIOs have a horizontal layering of flaky, lamellar, “micaceous” particles that overlap like scales on a fish and give strength and corrosion resistance to paints and coatings. Standard-grade MIOs are used on bridges, oil rigs, and other structural steel and as protective coatings on electrical and industrial equipment. Micronized grades are used in anticorrosive decorative coatings, including water-based coatings; in prime coatings, as partial replacement of zinc dust; and in certain applications requiring a degree of friction (O'Driscoll, 2012).

China.—IOP production in China was thought to have increased beginning in about 2006, as indicated in part by

a steady and substantial decrease in IOP imports from the United States to a negligible quantity in 2009, despite the country's ongoing urbanization. In 2010–14, however, IOP imports from the United States increased substantially, averaging nearly 30,000 t/yr, and reached a high of 39,600 t in 2015, returning to more than 90% of the average annual level for 2005–07 (U.S. International Trade Commission, undated). The increase in demand for IOPs in China mainly was driven by increased construction activity.

Hong Kong-based Cathay Industries Group, in a joint venture with the Tonghua Group, completed construction of and produced synthetic IOPs (black, red, and yellow) at their new 65,000-t/yr synthetic iron oxide plant in Tongling, Anhui Province, in eastern China. The plant included spray driers capable of producing 20,000 t/yr of pigment granules. A phased expansion of the joint-venture plant, known as Rely Science & Technology Co., Ltd., was planned for increasing the capacity to 85,000 t/yr by 2018 and to 150,000 t/yr thereafter (Lismore-Scott, 2014; Patel, 2015, 2016). Products would be targeted for markets in China, where demand had been increasing at a rate of 7% to 8% per year in most IOP-consuming industries. The new plant was designed to use a new direct precipitation process, an all-liquid phase method, which enhances water and waste gas treatment and significantly reduces liquid and solid waste. This plant was Cathay Industries' eighth IOP plant in China, along with those in Shenzhen, Guangdong Province, Shanghai, Shanghai Province, and Wuxi, Anhui Province (Cathay Industries Europe N.V., 2013; Ollett, 2013a; Lismore-Scott, 2014).

Lanxess AG completed construction of its 25,000-t/yr synthetic red IOP plant at the Ningbo Chemical Park in Ningbo, Zhejiang Province, at an estimated cost of \$75 million. Production of highly saturated red IOPs was planned to begin in the first half of 2016 using a newly developed and patented "Ningbo Process" that places particular emphasis on water treatment; waste gas cleaning, including a reduction of nitrous oxides generated; and lower energy consumption. Lanxess was in the process of building a 70,000-t/yr mixing and milling plant at the site. Lanxess also operated a 38,000-t/yr IOP plant in Jinshan, Shanghai Province, where it produced black and yellow IOPs (Ollett, 2013b, c; Sun, 2015).

Spain.—Promindsa SA, the country's leading producer of IOPs, produced and sold nearly 15,000 t of IOPs in 2015, about the same as in 2014, 85% of which was exported to more than 50 countries. The company expected to maintain production and sales at the same level in 2016. About 80% of Promindsa's IOP output and sales was red hematite, mostly from its 100-year-old "Santa Rosa" mine. Promindsa sold its Santa Rosa iron oxide as a red pigment for use in asphalt, brick, glass and ceramics, paints, and roof tile. The company also operated other deposits in the Provinces of Soria, Granada, Cordoba, Teruel, and Zaragoza, from which it mined black (magnetite), brown (oolitic iron ore), and yellow (goethite) IOPs (Promindsa SA, 2013). The company continued development of its Ojos Negros Mine, a goethite iron ore project with production of 600 to 1,000 t/yr of brown IOP expected to begin in 2016. The company also launched two new business units in 2015, one marketing special dispersion products for use in paints, agriculture, plastics, rubber, and cork, and the other for the treatment and

decontamination of contaminated soils or materials (Fernando Prada, President, Promindsa SA, written commun., May 25, 2016; Promindsa SA, 2016).

Outlook

With the global economic situation continuing to gradually improve, construction activity and consequent consumption of IOPs for coloring concrete, paints, and coatings is expected to follow. On a global scale, growth in the IOP market is expected to continue to increase during the next several years, mostly because of increased construction activity, especially in China, India, Indonesia, and the United States. Growth was projected to remain modest in the advanced economies, with stronger growth predicted in the emerging markets and developing economies in 2016 compared with 2015, but at a slower pace for the fifth consecutive year. Because economic uncertainties have continued following the regional debt crisis in Europe, capital spending on construction projects that use IOPs is expected to vary by region and country, and therefore in Europe, may be limited overall (Ollett, 2013b; Patel, 2015; International Monetary Fund, 2016, p. 2–3; MarketWatch, Inc., 2016).

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TABLE 1
SALIENT U.S. IRON OXIDE PIGMENTS STATISTICS¹

		2011	2012	2013	2014	2015
Crude pigments sold or used: ²						
Quantity	metric tons	W	W	W	W	W
Value	thousands	W	W	W	W	W
Finished pigments sold: ³						
Quantity	metric tons	48,000	48,400	47,200	45,300	53,500
Value	thousands	\$73,900	\$77,700	\$75,400	\$71,500	\$77,900
Exports: ⁴						
Quantity	metric tons	8,660	8,950	8,170	8,790	8,930
Value	thousands	\$15,000	\$13,500	\$13,400	\$16,000	\$17,200
Imports for consumption: ³						
Quantity	metric tons	158,000	151,000	165,000	175,000	176,000
Value	thousands	\$188,000	\$182,000	\$190,000	\$208,000	\$209,000

W Withheld to avoid disclosing company proprietary data.

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

²Mined.

³Natural (mined) and synthetic.

⁴Pigment grade.

TABLE 2
PRODUCERS OF IRON OXIDE PIGMENTS AND REGENERATED IRON OXIDES
IN THE UNITED STATES IN 2015

Producers	Plant location
Pigments:	
Crude:	
Alabama Pigments Co., LLC	Green Pond, AL.
Applied Minerals, Inc.	Eureka, UT.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Finished:	
Alabama Pigments Co., LLC	Green Pond, AL.
Applied Minerals, Inc.	Eureka, UT.
Dynamic Color Solutions, Inc.	Milwaukee, WI.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Prince Minerals, Inc.	Quincy, IL; and Bowmanstown, PA.
Huntsman Corp. (formerly Rockwood Pigments NA, Inc.)	Beltsville, MD; Cartersville, GA; King of Prussia, PA; Los Angeles, CA; and East St. Louis, MO.
Regenerator iron oxides:	
American Iron Oxide Co. ¹	Allenport, PA; Portage, IN; and Rockport, IN.
ArcelorMittal Weirton Inc.	Weirton, WV.
Bailey-PVS Oxides, LLC	Decatur, AL; Fairfield, AL; and Delta, OH.
International Steel Services, Inc.	Burns Harbor, IN; and Warren, OH.

¹Division of International Steel Services, Inc.

TABLE 3
U.S. EXPORTS OF IRON OXIDES AND HYDROXIDES, BY COUNTRY¹

Country	Pigment grade				Other grade			
	2014		2015		2014		2015	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	(2)	\$5	1	\$6	--	--	3	\$78
Australia	86	272	66	176	1,420	\$389	1,530	849
Belgium	1,200	4,760	902	4,560	74	291	100	635
Brazil	183	700	308	1,190	234	156	211	197
Canada	--	--	12	16	4,110	8,110	4,450	8,670
Chile	57	28	119	78	142	368	88	63
China	1,350	3,090	1,970	4,080	33,400	10,100	37,700	11,100
Colombia	82	273	51	241	11	95	28	178
Dominican Republic	2	21	19	69	2	67	2	7
France	44	225	38	207	61	34	1	12
Germany	4	32	51	501	819	370	291	794
Haiti	3	11	4	14	10	46	6	26
Hong Kong	2	14	4	28	10	24	9	18
India	103	218	41	156	93	440	125	502
Indonesia	2	27	2	9	11	55	(2)	4
Israel	13	31	--	--	620	201	844	316
Italy	4	60	12	44	20	17	91	77
Jamaica	11	45	1	4	--	--	7	14
Japan	10	63	12	80	41	37	26	23
Korea, Republic of	195	443	114	422	14	295	15	309
Malaysia	93	55	--	--	9	22	17	45
Mexico	4,160	2,820	4,360	2,740	3,290	2,390	3,190	2,260
Netherlands	21	121	5	15	44	115	16	8
New Zealand	--	--	10	46	4	17	17	33
Peru	22	36	2	21	(2)	6	15	29
Singapore	1	12	12	60	119	157	48	75
South Africa	4	24	4	23	--	--	8	46
Spain	20	64	31	130	14,200	3,860	8,120	1,540
Taiwan	17	110	131	390	106	644	75	654
Thailand	7	51	98	119	1,140	2,110	394	1,520
Trinidad and Tobago	1	3	7	17	15	16	30	33
United Arab Emirates	162	88	160	81	(2)	7	120	77
United Kingdom	331	604	328	1,460	451	1,270	344	1,290
Uruguay	99	374	--	--	43	162	219	806
Venezuela	236	611	1	15	27	32	58	58
Vietnam	30	186	--	--	4	21	2	11
Other	241 ^r	544 ^r	45	171	120 ^r	439 ^r	38	277
Total	8,790	16,000	8,930	17,200	60,600	32,400	58,200	32,700

^rRevised. -- Zero.

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

²Less than ½ unit.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF SELECTED IRON OXIDE AND HYDROXIDE PIGMENTS, BY TYPE¹

Type	2014		2015		Principal sources, 2015 (metric tons)
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)	
Natural:					
Earth colors ³	2,240	\$1,170	2,440	\$1,490	Cyprus, 2,200.
Micaceous	1,270	1,610	1,160	1,170	France, 590; Austria, 470; Spain, 76.
Total	3,510	2,780	3,600	2,660	
Synthetic:					
Black	49,200	50,300	49,300	55,000	China, 16,100; Germany, 15,700; Canada, 9,360.
Red	67,600	82,700	67,100	78,700	China, 45,500; Germany, 18,500.
Yellow	53,900	70,600	55,100	71,400	China, 27,600; Germany, 12,700; Brazil, 12,200.
Other ⁴	459	1,310	716	1,370	China, 440; Canada, 164.
Total	171,000	205,000	172,000	206,000	
Grand total	175,000	208,000	176,000	209,000	

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

²Customs value.

³Includes those not elsewhere specified or included.

⁴Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF IRON OXIDE AND IRON HYDROXIDE PIGMENTS, BY COUNTRY¹

Country	Natural				Synthetic			
	2014		2015		2014		2015	
	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)	Quantity (metric tons)	Value ² (thousands)
Austria	549	\$1,020	470	\$625	18	\$72	34	\$180
Belgium	--	--	--	--	4	17	195	383
Brazil	--	--	--	--	10,700	15,200	12,200	16,900
Canada	--	--	--	--	13,100	3,950	10,300	4,220
China	23	21	6	13	90,900	99,600	89,600	96,500
Colombia	--	--	--	--	2,440	3,670	2,340	3,500
Cyprus	2,210	1,060	2,210	1,120	--	--	--	--
France	590	485	593	491	249	1,880	195	1,660
Germany	1	4	--	--	42,200	54,100	46,800	57,900
Hong Kong	--	--	--	--	343	267	500	437
Italy	1	5	4	13	8,560	19,000	8,250	19,400
Japan	1	81	--	--	1,750	5,790	674	4,420
Netherlands	39	17	15	13	8	57	77	119
Spain	76	49	297	387	425	279	331	192
Other	18 ^r	42 ^r	--	--	479 ^r	943 ^r	662	631
Total	3,510	2,780	3,600	2,660	171,000	205,000	172,000	206,000

^rRevised. -- Zero.

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

²Customs value.

Source: U.S. Census Bureau.

TABLE 6
NATURAL IRON OXIDE PIGMENTS: ESTIMATED WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

Country ³	2011	2012	2013	2014	2015
Austria, micaceous iron oxide	3,590	3,400	3,400	3,500	3,500
Cyprus, umber ⁴	3,219	3,394	4,016	3,793 ^r	3,503
France	1,000	900	900	900 ^r	900
Germany	223,288 ⁴	204,198 ⁴	205,000	200,000	200,000
India, ocher ^{4,5}	1,218,261 ^r	1,576,265 ^r	1,833,783 ^r	1,580,675 ^r	2,203,708
Italy	112	118	137	140	150
Pakistan, ocher ^{4,6}	36,078	42,107	37,769	27,507 ^r	51,534
South Africa	266	--	--	--	--
Spain, ocher and red iron oxide	15,000	16,500	16,400	16,000	16,000
United States	W	W	W	W	W

^rRevised. W Withheld to avoid disclosing company proprietary data. -- Zero.

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

²Includes data available through February 16, 2017.

³In addition to the countries listed, a number of others produce iron oxide pigments, but output was not reported and no basis was available for formulating estimates of output levels. Such countries include Azerbaijan, Brazil, China, Honduras, Iran, Kazakhstan, Lithuania, Paraguay, Russia, Turkey, Ukraine, and the United Kingdom. Unreported output was probably substantial.

⁴Reported figure.

⁵Data are for fiscal year ending March 31 of the following year.

⁶Data are for fiscal year ending June 30 of the following year.