



# Infrared Absorbing Oxides

IRASORB | STANOSTAT

**Based in Stoke on Trent, the heartland of the British ceramics industry, Keeling & Walker were incorporated in 1916 as a supplier to the local potteries.**

The company quickly realized the importance of tin oxide as a key raw material for ceramic colour pigments. By the 1930s Keeling & Walker had established their own manufacturing process, which has set the industry standard to the present day.

Today Keeling & Walker is the world-wide leading manufacturer of tin oxide and its SUPERLITE brand is the most recognized in this market. With this background Keeling & Walker pioneered the development of antimony tin oxides, which excel in their antistatic and infrared light absorbing properties.

Keeling & Walker extended this knowledge further to develop and manufacture a wider range of advanced infrared absorbing oxides to match the demand for highly functional optical active materials tailored for a range of applications.

State of the art production facilities supported by a rigorous Quality Management System based on ISO 9001, 14001 and 50001 made it possible to introduce the IRASORB products to the polymer, inks and coatings industries.



OUR NEW PREMISES SINCE 2015



OUR ORIGINAL PREMISES FROM 1916

Keeling & Walker's technical consultancy and service ensures that IRASORB products deliver optimal performance and are adapted to any application requirement.

Continuous investment into research and development guarantees that the next generation of further improved and tailored products is on its way.

January 1, 1908.

THE POTTERY GAZETTE.

107

Telegrams—"Expedite, Stoke-on-Trent."

Codes Used—A.B.C. 5th Edition & Moreing & Neal's Mining.

Nat. Telephone No. 1026.

**KEELING & WALKER,**

*Flint and Stone Grinders. Manufacturers of Prepared Clay, Glazes, Silicates of Lead.*

**SUTHERLAND MILLS, STOKE-ON-TRENT.**

**SPECIALITIES:—**

**WHITE AND COLOURED OPAQUE ENAMELS FOR TILES.**

PREPARED EARTHENWARE BODIES & GLAZES.

GROUND FLINT, STONE, FELSPAR, & WHITING.

OXIDES OF TIN, COBALT, ZINC, IRON, COPPER, CHROME. WHITE & RED LEAD & POTTERS' CHEMICALS.

ENAMEL & UNDERGLAZE COLOURS, COLOURED GLAZES & SLIPS.

BALL & CHINA CLAY, PRESS CLOTHS, & POTTERS' SUNDRIES & STORES.

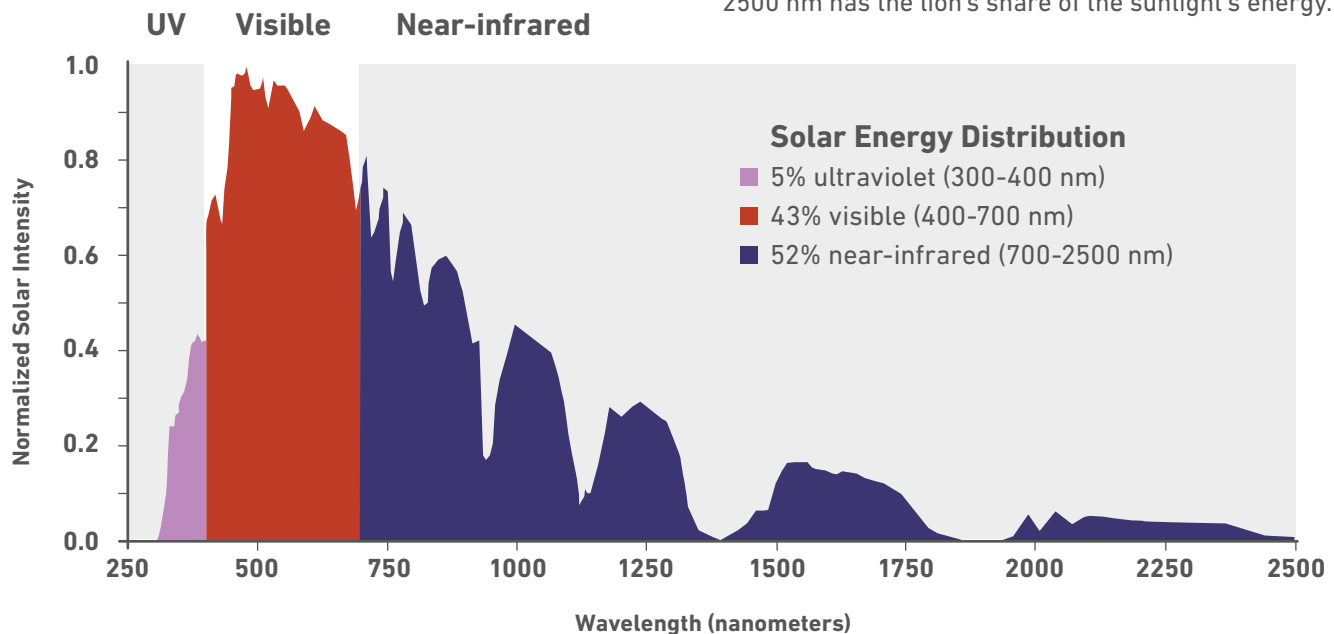
PRICE LIST ON APPLICATION.



## INFRARED LIGHT

**Sunlight consists not only of visible light but also of ultraviolet (UV) and infrared (IR) light.**

The visible part in the wavelength range between 400 – 700 nm makes up for 43 % of energy in sunlight, whereas the ultraviolet in the range between 250 – 400 nm has only a 5% share. With 52% the infrared light between 700 – 2500 nm has the lion's share of the sunlight's energy.



Infrared light can't be seen, but it is noticed as heat. As a consequence, on sunny days the heat build-up in buildings and vehicles can be a serious issue which in hotter areas requires extensive air conditioning to keep temperatures at a pleasant level.

The high energy cost and the environmental impact inspired search for alternative solutions. Solar control window films with nano dispersed NIR absorbers became one of the most successful developments. They combine very high transparency of visible light and strong absorption of NIR light. These features provide uncompromised brightness and clarity of the window and significantly reduced heat build up inside the room at the same time.

Infrared light also plays an important role in technical applications. Heating and drying processes in thermoplastic polymers, coating and ink applications are often accelerated by IR Light.

Fibres and Textiles absorbing NIR light enter the consumer markets. New applications in 3D printing driven by NIR light induced sintering of polymer powders emerge.

Materials designed to absorb near infrared light require a suitable electronic structure and a crystal lattice which allows the excitation of electrons.

**The chemistry of inorganic metallic oxides offers numerous options to create materials with the required properties. Introduction of additional elements into the crystal structure, or reduction processes to generate mixed – valence oxides are only a few options which Keeling & Walker use to create efficient infrared absorbing materials.**

## PRODUCT RANGE

### ANTIMONY TIN OXIDES

**Tin oxide is a white, inert and very stable material. Reacting tin oxide with other metal oxides leads to the formation of colour pigments, which are widely used in the ceramics industry.**

Based on this knowledge it was discovered that doping of tin oxide with various elements allows to alter its physical and chemical properties. For example, doping with antimony affects the electronic structure of tin oxide changing entirely the way the material interacts with electromagnetic radiation.

The electrical insulator tin oxide is converted into a semi-conducting oxide. The optical properties change as well. Whereas the transparency of thin layers in the visible light is maintained, a strong absorption of the near infrared light occurs.

Antimony is not just mixed with tin oxide, but it is strongly built in inside the tin oxide structure. It does not pose a high risk of toxic antimony being leached out of the product. Toxicological safety of our antimony doped tin oxide is confirmed by studies for REACH registration and indirect food contact compliance according to the EU regulations.

Keeling & Walker's 100 years' experience in tin oxide chemistry resulted in highly sophisticated, two distinct product lines : StanoStat CP and StanoStat CPM manufactured by proprietary processes.

### STANOSTAT CP RANGE

**The StanoStat CP range of antimony tin oxides combine semi-conductive properties with a very light grey colouration.**

The StanoStat CP products are high temperature stable ceramic materials, chemically inert and thus protected from environmental impact. Products made with CP grades show superior durability. The particle size can be adapted and ultrafine grades suitable for textile fibre applications are available.

The CP range typically has a spheroidal particle shape. They deagglomerate easily and disperse well in coatings and inks. No high energy grinding is suggested.

For polymer applications special grades of surface treated oxides are available.

CP products are designed for non-transparent applications, but opaque or translucent formulations are possible.

Product	Colour	L-value	Power resistivity (ohm*cm)	BET surface area (m <sup>2</sup> /g)	Particle size D50 (µm)
CP15G	Light blue-grey	82 – 86	10	6	0,8
CP40W	Light grey	90 – 94	100	4,4	0,8
CP05	Blueish	> 65	3	2	1,4
CP5C	Blueish-grey	78 - 82	4	3	1,0
CP5R	Light grey	86 - 90	8	7	0,4
CP5RM	Pale greenish- grey	78 - 82	15	9	n.a.
CP8C	Light grey	84 - 87	8	6	0,9



## APPLICATIONS

Product	Antistatic coatings	Laser marking and direct structuring additive	NIR absorbing coatings / inks	Drying accelerator	IR absorbing fibres
CP15G	✓			✓	
CP40W	✓		✓	✓	
CP05		✓			
CP5C	✓	✓	✓		✓
CP5R		✓	✓	✓	✓
CP5RM		✓	✓		✓
CP8C		✓	✓	✓	
CP150C		✓			

The unique properties – light colours, good electrical conductivity and high absorption of infrared and laser light - are exploited in a number of applications.

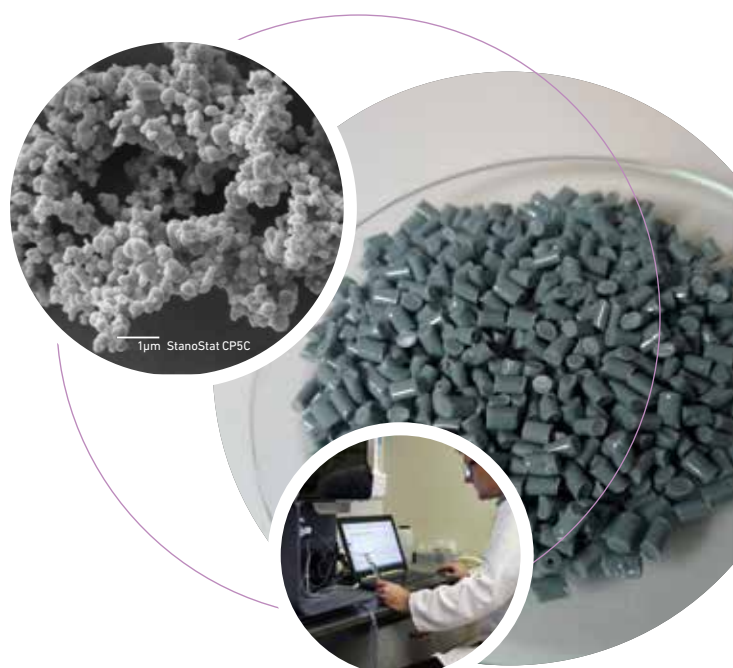
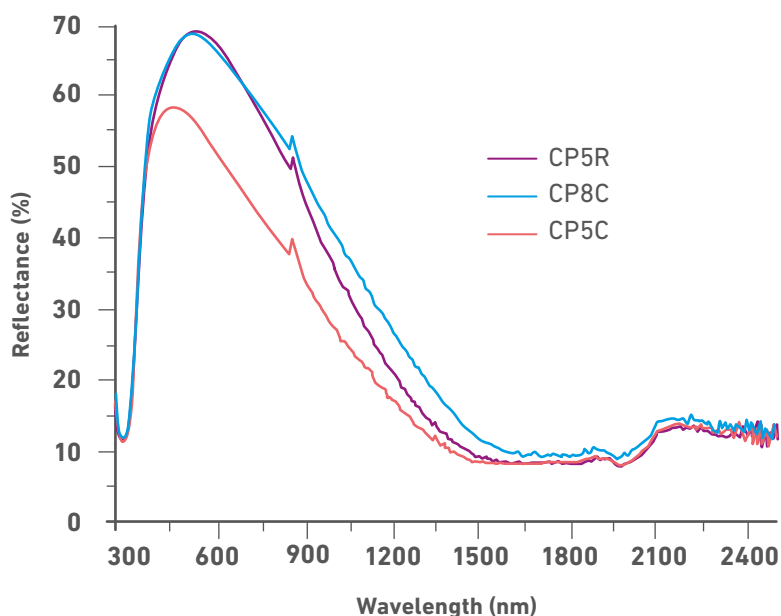
Certain CP grades will provide non-transparent, low coloured, durable antistatic coatings preferably in thin layers. Surface resistance of the coating will depend on the concentration of CP-additive. Their low colour and the permanency of the antistatic effect are advantages over other antistatic additives. A concentration over the percolation point is necessary to achieve good antistatic effects. Thanks to their IR absorption capability CP grades shorten at already low levels quite significantly the drying time of IR dried coatings. This enables shorter processing times and higher throughput of the drying units.

Low colour, infrared absorption and small particle size of CP5R and CP5RM grades make them an excellent choice for heat retaining polymeric fibres in clothing and other technical textiles. CP5RM offers additional advantage of having a hydrophobic surface functionalization which improves dispersibility in numerous polymers.

The high chemical inertness of the CP grades provides high mechanical and chemical stabilities to the fibres.

The good absorption of laser light and its conversion into heat are the features for applying the CP oxides as laser marking additives. The StanoStat products can be used as sole marking agent or in specific formulations.

## Powder Reflection Spectra of CP grades



## STANOSTAT CPM RANGE

The StanoStat CPM range are deep blue coloured, nanosized antimony tin oxides, perfect for inks and dispersions.

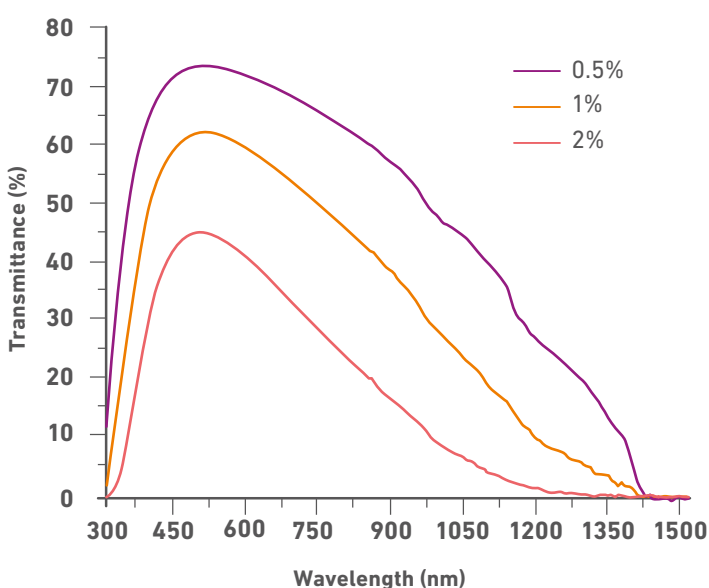
StanoStat CPM materials consist of nanoscale primary particles, bound into larger agglomerates in powder form. Milling and technical know-how are required to successfully deagglomerate CPM powders. After years of research and investment into state of the art milling facilities, Keeling & Walker mastered manufacturing of nanodispersed CPM grades.

The CPM dispersions show an almost linear increase in IR absorption starting from 950 nm to maximum absorption at 1250 nm. For direct incorporation into masterbatches the use of solid powders is preferred. StanoStat CPM10M offers an excellent dispersibility in the polymer melt during the extrusion process.

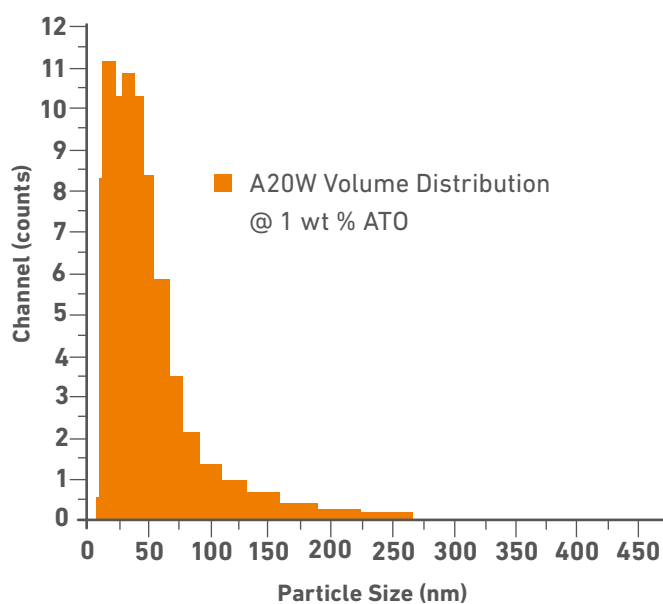
As ceramic material the CPM grades are inert against polymers and offer highest stability against chemical and environmental influences to ensure a long service life of the final products.



### Transmission Spectra of A20W Nanodispersion



### Typical Particle Size Distribution of A20W



## SOLID PRODUCTS

Product	Composition	Colour	Thermal stability	Max. IR powder absorption	BET surface area (m <sup>2</sup> /g)*	Powder resistivity (ohm*cm)*	Apparent density (g/l)*	Particle size D50 (µm)*
StanoStat CPM05C	Antimony Tin Oxide	Blue-grey	1000°C	1250 nm	35	0,3	1000	3
StanoStat CPM10C	Antimony Tin Oxide	Blue-grey	1000°C	1250 nm	50	0,3	1000	3
StanoStat CPM10F	Antimony Tin Oxide	Blue-grey	1000°C	1250 nm	50	0,3	1100	2.5
StanoStat CPM10M	Antimony Tin Oxide	Blue-grey	300°C	1250 nm	35	12	2200	6

## NANODISPERSIONS

Product	Active matter	Solvent	Colour	Solids content	Particle size by DLS*	pH	Availability
A20W	CPM10C	Water	Dark-blue	15 - 40%	60 nm	8 - 10	Commercial
A20WN	CPM10C	Water	Dark-blue	20%	60 nm	8 - 10	Commercial
A20E	CPM10M	Exxsol D140	Dark-blue	20%	< 100 nm		Pilot
A20BA	CPM10C	Butylacetate	Dark-blue	20%	40 nm		Pilot

\* Approximate values



## IRASORB INDIUM TIN OXIDES

Indium tin oxides (ITO) are known for their use as a transparent conductive oxide in electronic applications. Converting the typically yellow ITO by a proprietary process into its blue version significantly increases the ability to absorb IR light without compromising the transparency.

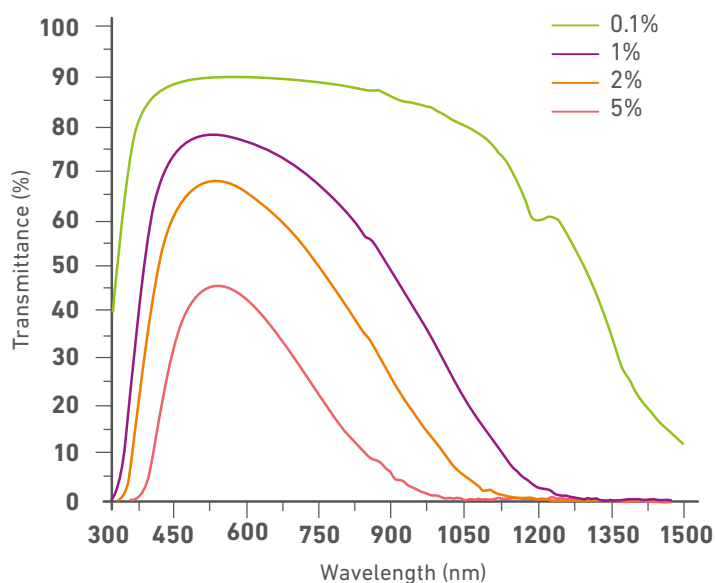
IRASORB BITO and BITO M40 are easy to be dispersed powders in polymers during the extrusion or injection moulding process. They disintegrate readily to nanoscale particles to form transparent polymer sheets and plates.

IRASORB BITO M40 offers good hydrophobicity which makes it easy to integrate into nonpolar polymers or liquid formulations.

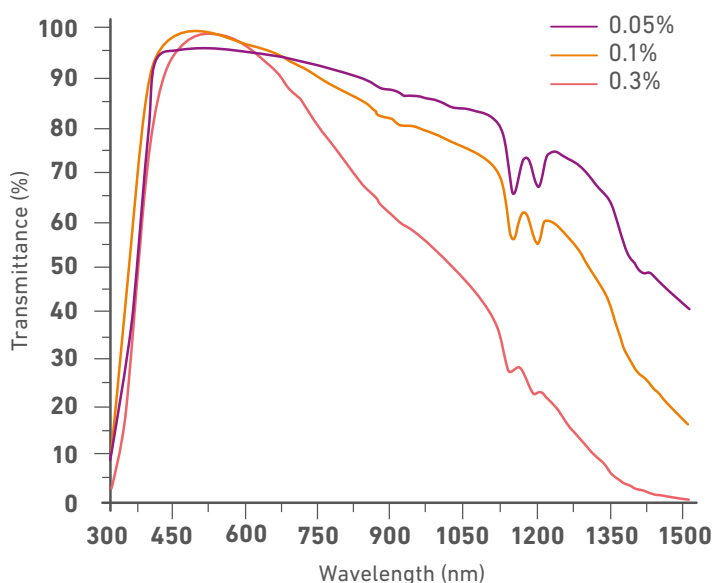
From all IRASORB products, BITO has the highest transparency in the visible range of wavelengths and at the same time it maintains high absorption of NIR light. The strength of NIR absorption and its maximum value depend mainly on the concentration of BITO and the thickness of the polymeric films or plates.



### Transmission Spectra of B20P



### Transmission Spectra of BITO in Polycarbonate 3mm





## SOLID PRODUCTS

Product	Composition	Colour	Thermal stability	Max. IR powder absorption	BET surface area (m <sup>2</sup> /g)	Powder resistivity (ohm*cm)
IRASORB YITO	Indium Tin Oxide	Yellow	800°C	1700 nm	> 40	< 10
IRASORB BITO	Indium Tin Oxide	Blue	800°C	1100 nm	> 30	0,2
IRASORB BITO M40	Indium Tin Oxide	Blue	400°C	1100 nm	30	< 10
IRASORB GITO	In <sub>4</sub> Sn <sub>3</sub> O <sub>12</sub>	Dark yellow	1400°C	1500 nm	< 10	< 100

## NANODISPERSIONS

Product	Active matter	Solvent	Colour	Solids content	Particle size by DLS	Availability
B20P	BITO	Plasticizer	Dark blue	20%	< 30 nm	Commercial
B20W	BITO	Water	Dark blue	20%	< 40 nm	Pilot
B20BA	BITO	Butylacetate	Dark blue	20%	< 50 nm	Experimental



## DOPED TUNGSTEN OXIDES

### Tungsten Oxides are the basis for the strongest NIR absorber in the product portfolio of Keeling & Walker.

Tungsten Oxides offer a multifaceted chemistry providing many options to modify and manipulate their chemical and physical properties.

Manipulation of the crystal structure and doping with other metals increases the NIR absorption significantly. Changes in electronic structure induced by cations lead to a strong local surface plasmon resonance causing strong and broad absorption in the NIR region.

Dependent on these changes and dopants the rate of transparency and absorption in the visible and NIR wavelength range can be tailored.

The IRASORB doped Tungsten Oxides are available as powders and dispersions. In order to benefit from the superior NIR absorption properties it is necessary to ensure the highest possible degree of dispersion in the chosen substrate.

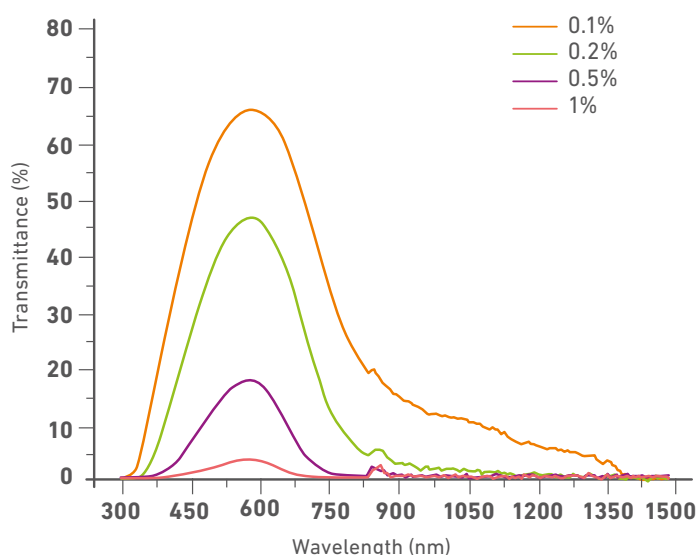
The CTOM10 grade offers very high clarity in the visible range and a sharp increase of absorption from 900 nm onwards. The CTOM10 grade shows the great advantage that it can be easily incorporated into polymers. It is especially well dispersible in polymers and solvent based coatings or inks under conventional conditions.

CTO20 and RTO offer excellent dispersability in water and various solvents. If more absorption in the visible range is desired, then RTOM is a good choice.

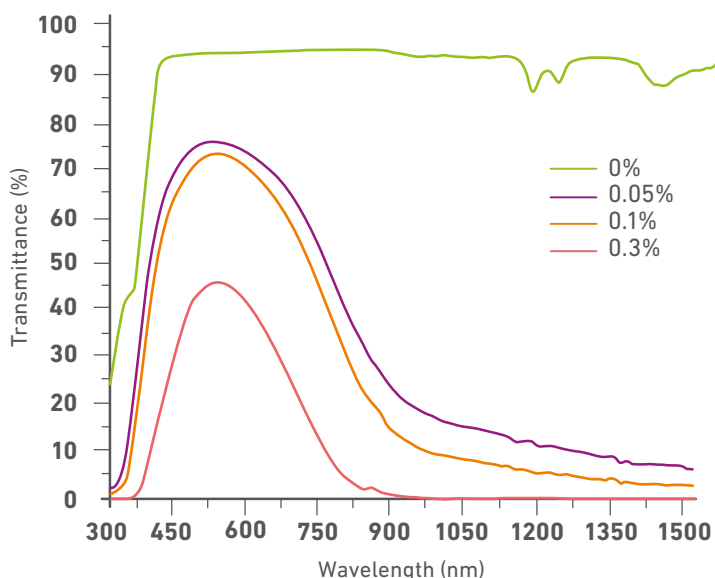
IRASORB NTO offers unique optical properties. The NTO based dispersions show high NIR absorbance already around 800 nm.

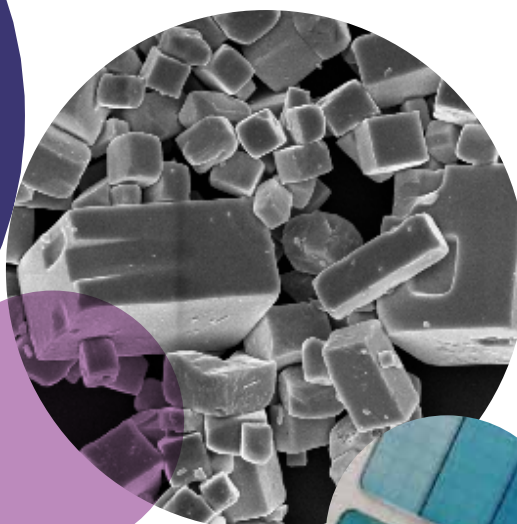
IRASORB Tungsten Oxides are designed for long service life and are stabilized against degradation. This makes them one of the best choices for solar heat control window films.

#### Transmission Spectra of C20W Dispersion



#### IRASORB CTO M10 in Polycarbonate 1mm





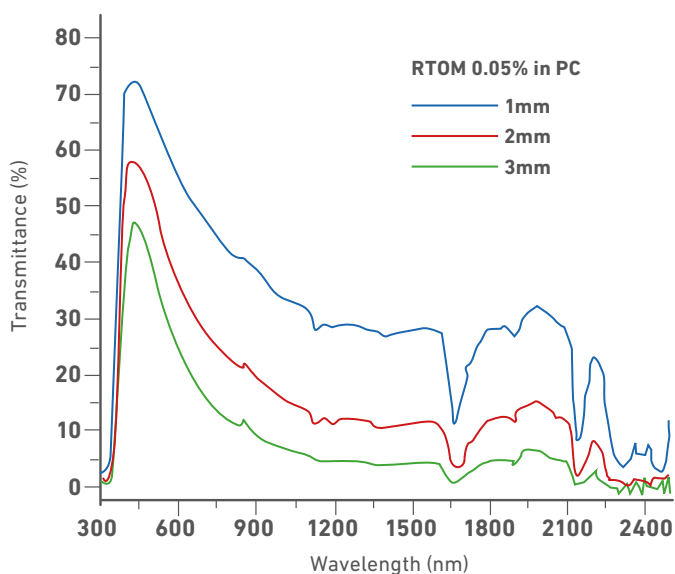
## SOLID PRODUCTS

Product	Composition	Colour	Thermal stability	BET surface area (m <sup>2</sup> /g)	Bulk density (g/l)	Max. IR powder absorption
IRASORB CTO20	Doped Tungsten Oxide	Dark blue	800°C	> 20	2000 - 2400	900 nm
IRASORB CTO M10	Doped Tungsten Oxide	Dark blue	350°C	> 10	1500 - 2200	900 nm
IRASORB RTO	Tungsten Oxide	Purple	800°C	1 - 2	1500 - 2000	1000 nm
IRASORB RTOM	Tungsten Oxide	Dark purple	350°C	10 - 15	1800 - 2000	1000 nm
IRASORB NTO	Doped Tungsten Oxide	Orange	600°C	1	2000 - 2400	1000 nm

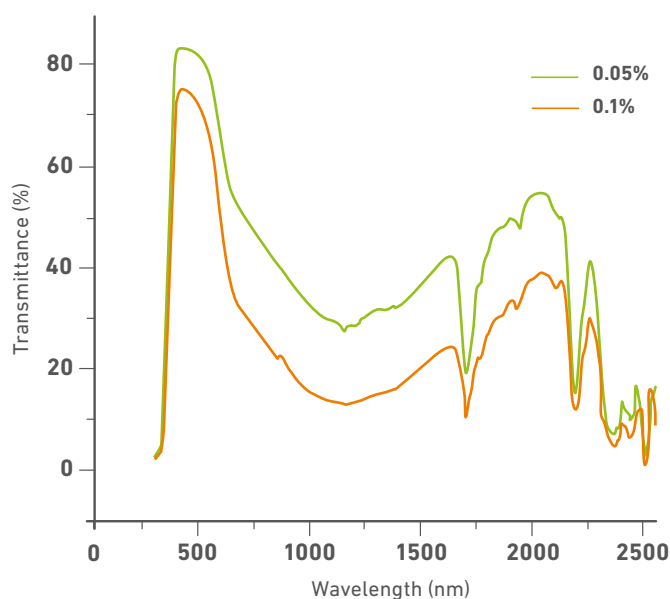
## NANODISPERSIONS

Product	Active matter	Solvent	Colour	Solids content	Particle Size by DLS	pH	Availability
C20W	CTO	Water	Dark-blue	20%	< 100 nm	3 - 4	Commercial
C20BA/C40BA	CTO	Butylacetate	Dark-blue	20% or 40%	< 50 nm		Pilot
N20I	NTO	1-propanol	Blue	20%	< 80 nm		Pilot

**IRASORB RTOM, 0,05%, in Polycarbonate**



**IRASORB NTO in Polycarbonate 1mm**



## APPLICATIONS OF NIR ABSORBING MATERIALS

The StanoStat and IRASORB products are versatile materials, wherever infrared light needs to be absorbed. The basic function of the absorbers is utilizing the photothermal effect: infrared light is absorbed and converted to heat, which is then dissipated into the surrounding matrix.

Major applications include:

Criteria	StanoStat CPM	IRASORB BITO	IRASORB CTO	IRASORB RTOM	IRASORB NTO
NIR Max. Absorption	1250 nm	1100 nm	900 nm	1000 nm	1000 nm
Efficiency	Good	Very good	Excellent	Excellent	Excellent
Transparency in visible range	Good	Excellent	Good	Good	Excellent
Coloration of the final product	Medium	Low	High	High	Medium
Thermal Stability	Excellent	Good	Good	Good	Excellent
UV Stability	Excellent	Excellent	Good	Good	Excellent
Tendency to agglomeration	High	Low	Medium	Medium	Low

## DRYING / CURING ACCELERATORS

The ability to influence the drying speed of coatings or inks is essential for the effectiveness of many processes. For example the drying time of waterborne inkjet inks is essential for the printing speed. The use of NIR drying equipment is state of the art. Further improvement can be achieved when NIR absorbers are incorporated into the inkjet inks.

The same principle applies for coatings on metals by continuous processes.

In construction materials like plasters, rendering and other surface coatings the addition of NIR absorbers help to increase the evaporation rate of water from rainfall or condensation and provide a dry surface. This limits the growth of unwanted algae on light surfaces.

## SOLAR PROTECTION FILMS / IR CUT FILMS

IRASORB materials are widely used in the production of solar protection films for automotive windows. The additives are not only used in films for side or rear windows, but due to their exceptionally good transparency also on front windows.

NIR absorbers increasingly find use for construction applications in windows, double or multiwall transparent polymer sheets etc. either in the form of coatings or directly incorporated into the substrate.

They are part of smart windows, which can change the degree of shading by the press of a button. Infrared absorbers help to increase vegetable production in greenhouse films, especially in colder climates.

They are also included in goggles, vizors and head shields, where the infrared absorbers protect the human eyes from intensive light influence. This makes them an indispensable part of personal protection equipment as well as for fashionable items.

## REHEATING ADDITIVES / CURING ACCELERATORS

IR absorbers are used on applications where polymer preforms are irradiated by infrared light sources to soften them for further processing like injection blow moulding process or thermoforming. The addition of NIR absorbers into the preform enable shorter processing time.



## FIBRE MODIFICATION

The ability of the NIR absorbers to convert IR light to heat is beneficial for outdoor textile applications. Nanoscale NIR absorber coated on or extruded with synthetic fibres improve the heat retention of clothing and other textiles. In cold climates especially, the NIR part of the sunlight helps to warm up the clothing and protects against the harsh climate.

## NIR ABSORBING INKS

One example is inks for brand protection application, another is inks for brand protection applications. Another one are inks for Photonic printing, where a patch of laser sensitive ink is printed on packaging material and the information is inscribed by a Laser. This process allows a high degree of personalisation at a high printing speed.

New Laser based printing technologies like LIFT (Laser Induced Forward Transfer) printing are now emerging and will make use of NIR absorbers as well.







### 3D PRINTING

Additive manufacturing has now established itself as a valuable process for the industry. Besides the filament based printing processes, polymer powder printing processes are also gaining popularity.

A bed of polymer powder is either laser sintered to form the piece or the structuring is printed with NIR absorbing ink onto the surface, which is then fused with NIR light.

Again the strong photothermal effect of the NIR absorbers is used to provide the conversion of the NIR light into heat for fusing the polymers. The IRASORB products provide a low coloration in to the polymers allowing a high freedom of design and colour to the application.

### LASER APPLICATIONS

Most common NIR laser machines operate at 1064 nm, whereas Fibre Lasers operate at wavelength between 780 and 2200 nm. StanoStat and IRASORB products are the preferred absorbers in the formulation of laser marking additives for polymer, glass and ceramic formulations.

Their broad absorption profile makes them especially suitable for perfect results with a range of Laser equipment. They are also useful as laser additives in Laser Direct Structuring (LDS) processes enabling the production of highly integrated electronic parts.

Fusing polymers by Laser Welding has developed into an important industrial process. IRASORB additives help to facilitate the welding process due to their strong photothermal effect, which softens or melts the polymer under the influence of Laser Light.



Additive for	StanoStat CP	StanoStat CPM	IRASORB BITO	IRASORB CTO	IRASORB RTO	IRASORB NTO
3D Printing		✓	✓	✓		✓
Antistatic Film		✓	✓			
Antistatic Fibre	✓	✓	✓			
Agricultural Film		✓		✓		
Automotive Window Film		✓	✓	✓		✓
Brand Protection	✓	✓	✓	✓	✓	✓
Curing and Drying Accelerator	✓	✓	✓	✓		✓
Heat Retention Fibre	✓	✓		✓		
Laser Marking	✓	✓	✓			
Laser Direct Structuring	✓	✓	✓			
Laser Welding			✓	✓		
NIR Absorbing Inks & Coatings		✓	✓	✓	✓	✓
NIR Absorbing Twin/ Multi Wall Sheets	✓	✓	✓	✓	✓	✓
Optical Filter			✓	✓	✓	✓
Photothermal Applications	✓	✓	✓	✓	✓	✓
Personal Protection Equipment		✓	✓	✓		✓
Reheating Additive	✓	✓		✓		
Transparent Water Heaters				✓	✓	✓



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