

Alcotac® – synergistic organic binders

 **BASF**

We create chemistry

BASF's Mining Solutions at a glance



BASF's Mining Solutions business offers a diverse range of chemicals and technologies for mineral processing to improve process efficiencies and aid the economical extraction of valuable resources.

We offer our products and technology solutions to the global mineral processing industry along with expert advice and technical support. Our global team is driven by a common goal to provide the best sustainable solution to meet our customers' processing needs. With technical representation in over 100 countries, BASF's technical support is provided on a global, regional and local basis.

We can provide reagents, equipment, process technologies and expertise, focusing on applications such as flotation, solid liquid separation, solvent extraction, tailings management, grinding, and materials handling.

Alcotac® synergistic organic binders

Agglomeration of fine grained minerals is widely employed in the mining industry. The addition of binders is critical to prevent the breakdown of the agglomerates during processing. BASF's Alcotac® synergistic organic binders have been successfully applied in the industry for more than 30 years to agglomerate a wide variety of mineral substrates.

Principal uses of the Alcotac® range include full or partial replacement of bentonite or lime binders in iron ore pelletization, and green strength enhancers in briquetting, granulating and extruding processes.

Alcotac® binders are synthetic in nature and therefore can be supplied in consistent quality. They are efficient at very low use rates and help to reduce the amount of unwanted impurities while increasing operational efficiency at the same time.

Fig. 1: Alcotac® product range and application areas

Alcotac® series	Application areas	Chemical nature	Delivery form
Alcotac® CB8, CB11	Nickel, coal agglomeration	Polyacrylate, aqueous solution	Liquid
Alcotac® FE14	e. g. coal, ferro-alloys, and mixed fines agglomeration	Anionic polyacrylamide	Powder
Alcotac® FE-16	Iron ore pelletization	Anionic polyacrylamide blend	Powder
Alcotac® CS, CS-A	Iron ore pelletization	Modified anionic polyacrylamide blend	Powder

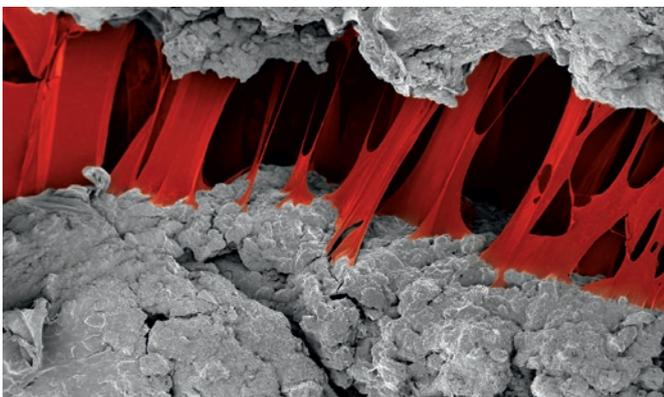


Fig. 2: Electron microscope image illustrating the synergistic interaction of Alcotac® CS with bentonite

Alcotac® synergistic organic binders in iron ore pelletization

When pelletizing iron ore, the addition of small amounts of the synergistic organic binder Alcotac® saves up to 60% of the bentonite dosage, resulting in a reduction of silica and alumina impurities and less logistic handling. Plant operators can operate more efficiently without compromising pellet quality.



Fig. 3: Industrial scale pelletization process

With the depletion of higher grade ore deposits, the extraction of lower grade ores gained in importance. The ores are ground to a fine particle size to separate unwanted impurities and concentrate the iron oxide. The fine grain of the concentrate is then agglomerated into larger particles to allow further processing in blast furnaces. The most common technology in the iron ore industry to agglomerate concentrate fines is pelletization.

Binders are used to make the moist ore plastic so that seeds are nucleated and pellets grow at a controlled rate. The binder holds the green pellet together until strong bonds are formed in the induration process where the agglomerates sinter together at temperatures of around 1300 °C.

Bentonite was the first binder used and is still employed today by most pellet plants.

However, bentonite also has the disadvantage to introduce unwanted impurities like silica, alumina or even sulfur.

It is worth noting that pellets with elevated levels of impurities are valued lower in the market place.

Reduction of bentonite by adding Alcotac®

Thanks to BASF's capabilities and the broad expertise of its dedicated binder team, BASF Mining Solutions is able to provide individual advice and ready-to-use solutions that help customers improve their environmental footprint by reducing unwanted impurities, fuel consumption (blast furnace), traffic and waste.

Hydrophilic organic polymers can strongly interact with bentonite clays, thereby modifying their crystalline structure and also changing their macroscopic properties.

BASF has made considerable research and development efforts to create innovative chemistry that can significantly improve the performance of polymer-bentonite binder systems. Alcotac® FE grades and Alcotac® CS have been designed to replace a substantial portion of bentonite at very low dosage while maintaining the mechanical properties of the pellets.¹

Due to excellent moisture control behaviors, Alcotac® binders enhance the balling process. A better process efficiency is also achieved as a higher yield of pellets within target size is produced.

As the organic polymer in Alcotac® binders leaves no residues in the induration process, the commercial value of fired pellets is increased because of lower silica and alumina impurities compared to the high dosage bentonite reference case.

Furthermore, Alcotac® helps to improve pellet reducibility because of a higher porosity.

The energy fuel savings is a well documented effect when organic binders are used to replace bentonite volumes

1. The organic binder burns during the induration process (up to 1350 °C), leaving a higher porosity of the pellet (2–3% higher). A more porous pellet has a higher rate of mass transfer in the blast furnace when the iron oxide is reduced to iron. This higher mass transfer saves fuel.
2. The reduced bentonite content means less silica and alumina is added to the pellet. Marginal lower silica levels (0.2–0.4%) have a significant reduction in the slag volumes produced in the blast furnace. Alumina, in the other hand, increases the viscosity of the slag. The combined reduction of both Silica and Alumina, imply a lower volume and less viscous slag, which reduces the fuel consumption as well.



Fig. 4: Iron ore pellets produced from a magnetite ore in the lab

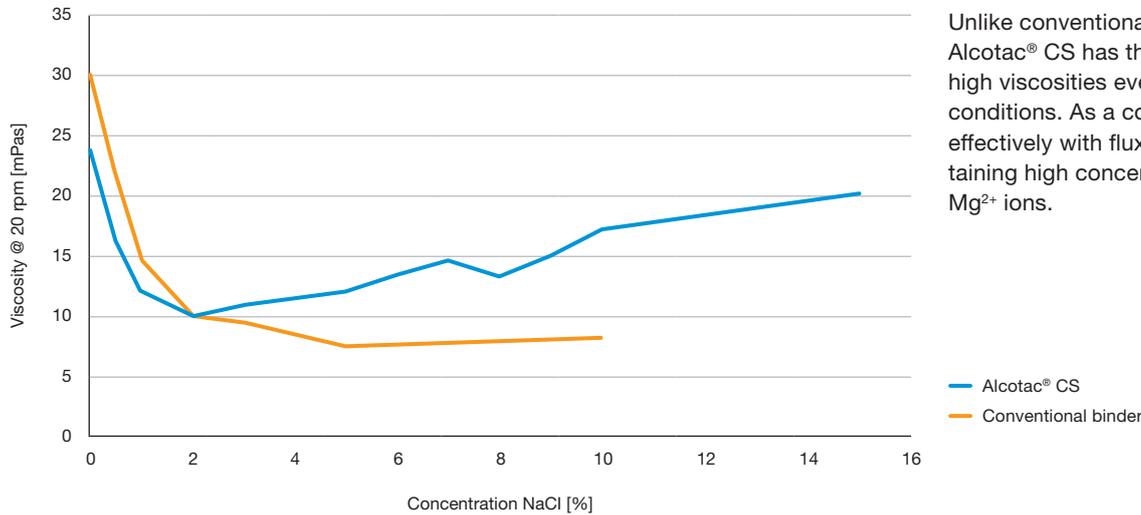
Alcotac® FE – organic binder for non-fluxed pellets

Alcotac® FE14 and FE-16 binders comprise synthetic, water soluble polyacrylamides which provide high green pellet strength at a very low use level (approx. 200 g per ton of ore, or even less).

Alcotac® FE binders are added to the concentrate feed in powder form, therefore, no special mixing equipment is required on site to make up solutions.

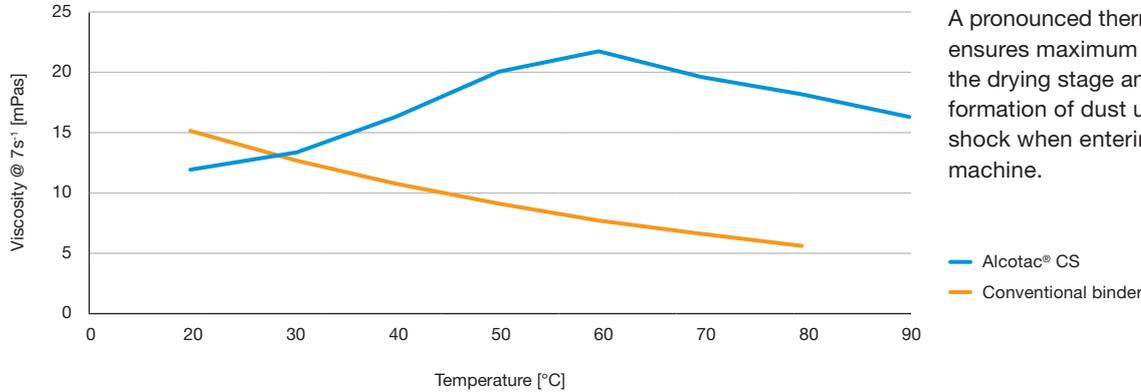
Alcotac® CS outperforms conventional organic binders

Fig. 5: **Viscosity of 0.2% aqueous polymer solutions with variation of salinity. Viscosity of Alcotac® CS outperforms the conventional binder polymer at high salinities.**



Unlike conventional polymeric binders, Alcotac® CS has the ability of developing high viscosities even under high salinity conditions. As a consequence, it works effectively with fluxed pellet feeds containing high concentrations of Ca^{2+} and Mg^{2+} ions.

Fig. 6: **Viscosity of 0.2% aqueous polymer solutions at different temperatures. Alcotac® CS has a thermo-thickening behavior.**



A pronounced thermo-thickening behavior ensures maximum pellet strength during the drying stage and minimizes the formation of dust upon the first thermal shock when entering the induration machine.

Alcotac® CS for demanding conditions

A challenge exists when using anionically modified organic binders in fluxed pellets where calcium and magnesium ions are present. These ions negatively interact with the organic binder polymer which becomes less effective.

Alcotac® CS has been developed to overcome these challenges. Due to a unique chemical design, Alcotac® CS strongly interacts with bentonite clays even when bivalent ions such as calcium or magnesium are present. As demonstrated by scanning electron microscopy, Alcotac® CS when mixed with bentonite strongly adsorbs to the bentonite surface where it increases porosity thus improving the performance as a binder.

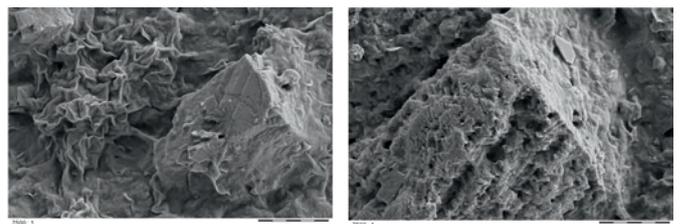
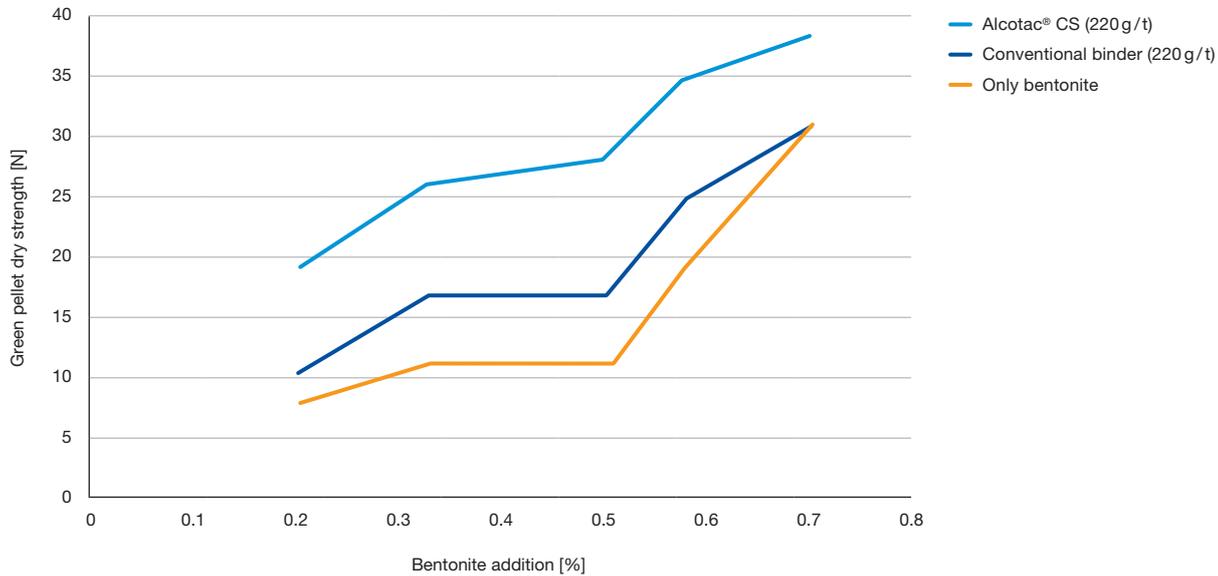


Fig. 7: **SEM photomicrographs of dried bentonite (left) and bentonite plus Alcotac® CS (right).**

Dry strength

Fig. 8: Dry strength of pellets obtained from agglomeration experiments



Bentonite addition (%)	Dry strength (N)			Increase in strength due to organic binder addition (N)		Ratio of strength increase
	Only bentonite	Conventional binder (220 g/t)	Alcotac® CS (220 g/t)	Conventional binder	Alcotac® CS	Alcotac® CS / Conventional binder
0.22%	8.0	10.7	19.1	2.7	11.1	4.2
0.34%	11.1	16.9	26.2	5.8	15.1	2.6
0.49%	11.1	16.9	27.6	5.8	16.5	2.8
0.49%	19.1	24.9	34.2	5.8	15.1	2.6
0.67%	30.7	30.7	37.8	0.1	7.1	very high

Alcotac® benefits at a glance

- Substantial reduction of bentonite usage at very low Alcotac® dose levels (< 200g per ton of ore)
- Good pellet growth properties by improved moisture control
- Improved plant efficiency by enhanced balling performance with less spelt material being rejected by the roll screens
- Increased commercial value of the fired pellets because of less silica and alumina impurities
- Improved metallurgical parameters of the fired pellet (e.g. enhanced reducibility due to higher porosity)

Briquetting and extrusion with Alcotac[®] CB and FE organic binders

Waste fines are currently a challenge within many industries associated with mineral beneficiation, power generation and steel manufacturing. Alcotac[®] organic binders can aid the recycling of such waste streams and offer many additional benefits against conventional binders.



Fig. 9: Conventional binder types²

Binder type	Positive features	Draw-backs
Bentonite	Green strength	High volumes needed Calorific value reduction and global quality is on the decline
Polyvinyl alcohol	Waterproof when cured	Capex & Opex to run boiler as well as excessive fines produced during briquetting processes
Polymers	Strength & waterproofing	Expensive per kilogram although cost of operations are comparable
Molasses + lime	Cured strength	High volumes needed and can produce excessive fines

Economic benefits using Alcotac® CB and FE organic binders

Since mineral grades are depleted globally, the quality and grade of inorganic binders can vary widely. Alcotac® organic binders make it easy to control quality and final agglomerate performance. Whilst the cost per unit is typically higher for processed polymers compared to commodity inorganics, it is nevertheless known that the cost of treatment per tonne of fines is cost comparable with the required binder dosage (grams per tonne) being significantly lower. Whilst typically no interactions occur with inorganics other than bentonite, the Alcotac® binders are fully compatible, should such a blend be desirable in the final agglomerate composition.

Fig. 10: **Inorganic binders vs. organic binders**

Binder chemistry	Typical dosage (%)	Binder dose (kg per tonne fines)
Molasses	6.0	60.0
Lime	1.0	10.0
Alcotac® organic binder	0.1–0.8	1.0–8.0
Polyvinyl alcohol	3.0	30.0

Use of Alcotac® binders provide several benefits:

- Improved handleability of final agglomerate
- Ability to control curing characteristics to required level
- Better green strength than conventional binder systems
- Lower logistics costs along supply chain
- Elimination or reduction of inorganics such as molasses and lime and PVOH
- Cost effective dose per tonne of agglomerates
- Easy to apply
- Improved final metal content in final product
- Flexible chemistry portfolio for difficult materials
- Proven hot strength capabilities despite low addition rates



The use of Alcotac® organic binders into pressurised agglomeration processes can greatly assist in reducing the total amount of binder required, ensuring a consistent higher mineral yield for a given process throughput without introducing impurities such as sulphur³. Considering the addition of Alcotac® binders to the process via a simple screw-feeder system, improved handleability is also a positive process benefit when comparing to preparation-intensive binders such as Polyvinyl alcohol⁴ or molasses and lime. Alcotac® binders can be handled in lower volumes and do not require a significant cleaning downtime.

Alcotac® organic binders offer the end-user an enhanced process stability and the opportunity to produce a final recycle product. When Alcotac® binders are used to aid agglomeration in ferro-alloy fines, the resulting agglomerates contain a higher metal value and improved combustion characteristics due to elimination of inorganic impurities to the furnace.

Fig. 11: **Effect of Alcotac® on compression strength of briquetted coal fines**

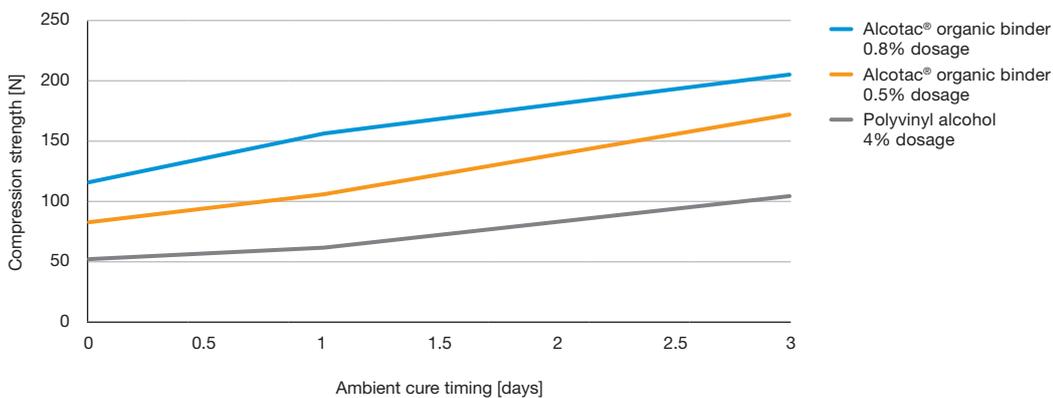
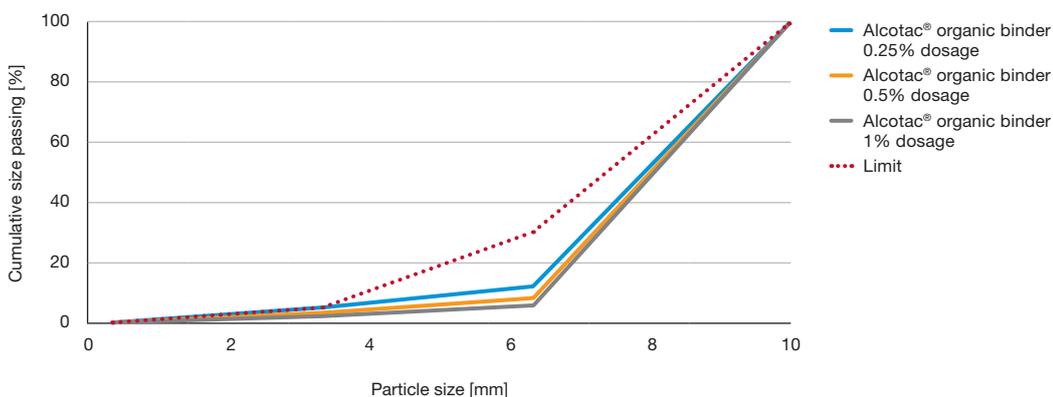


Fig. 12: **Effect of Alcotac® on reduction-disintegration at 980 °C**



BASF's market approach for Alcotac® binders

A structured approach to customer projects is executed to maximise turnaround time from concept to full-scale process with consistently representative results for scale-up.

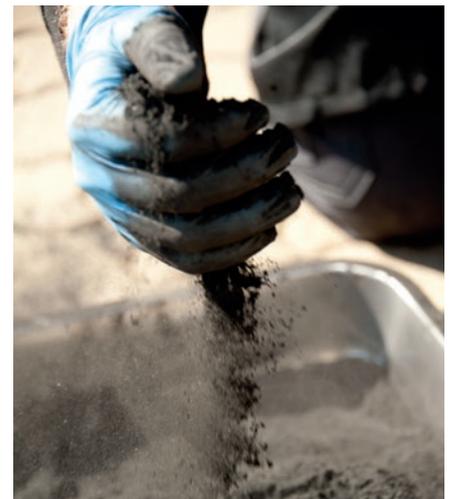


- A phase of initial reagent screening followed by statistical modelling to optimise performance and cost of treatment is carried out by BASF technical experts or in collaboration with the customer's metallurgists to assess the optimum chemistry system for the fines material in terms of cost and performance.
- Pilot scale trials are then typical with additional combustibility and tumble testing to further assess likely performance of BASF Alcotac® binders on full-scale.
- Full-scale trials are then performed with on-site assistance from BASF technical experts to advise on best application conditions to maximise yield and process benefits.

BASF Mining Solutions offer full technical consultation to recommend customized process solutions for the agglomeration of:

- Coal: Thermal and anthracite
- Iron ore: Ilmenite, haematite and/or magnetite
- Base metals ore
- Ferro-alloys: FeMn, FeCr, FeNb, FeSi
- Metal powder: Nickel, chrome
- Fluorspar
- Mill scale, DRI, off gas dust
- Industrial minerals

BASF Technical Agglomeration Centres in Germany, South Africa and North America are fully equipped to select the most cost-effective and process-viable binder, from feasibility to pilot and then to full-scale process.



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