SuperSaver™

Coal Enhancer

BLUE SEA
BIOTECH

Introduction to ***SuperSaver***™ Biotech Coal Enhancer

Green Coal and Environmentally Friendly Solution

A biotech enzyme product for lowering coal consumption, reducing SO_X, NO_X, CO_2 emission and preventing hot corrosion.

SuperSaver by BlueSea Biotech is a long lasting, environmentally friendly and energy saving nano-catalytic combustion-supporting solution. The solution is diluted with water before use and sprayed over coal normally 12~72 hours prior to coal ignition.

It simultaneously improves the burning and affinity of oxygen in the coal and reduces the level of oxygen required to achieve complete combustion. This is approached through ameliorating the usually inevitable fouling of the metal furnace wall caused by corrosive sulfur, removing accumulated fouling/coke on combustion chamber and heat exchanger, thus improving heat exchange efficiency. Using SuperSaver will demonstrate a remarkable saving in coal consumption , as well as a significant reduction in the formation of harmful sulphur oxides, nitrogen oxides, carbon monoxide and waste heat emissions , which will also extend the life of facilities, lower the cost of maintenance, and prevent calorie losses and spontaneous combustion of coal during storage.

SuperSaver is cost effective, simple to use (no furnace/boilers modification required), ready to apply straight out of the box and is adaptable for various types of boilers and furnaces (pulverized coal furnaces, fluidised bed furnaces, chain grate furnaces and cement furnaces …etc.).

BLUE SEA BIOTECH

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Contents

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Product Specifications

SuperSaver™

Name of product
SuperSaver "Coal Enhancer"

Appearance
Light Yellow, Transparent Liquid

Density
1.02 kg/litre

Viscosity
<10 cps

Chemical Characteristics
Non-toxic, no secondary pollutants, non-corrosive, non-flammable.

Product Accreditation
ISO 9001 Quality management systems.

Application
Suitable for all coal burning systems and products.

Usage/Dosages
1:10,000
(one tonne of SuperSaver for every 10,000 tonnes of coal)

Product Function
It improves the efficiency of coal combustion, improves the oxygen content in coal (reduces air intake needed), improves heat exchange rate, reduces SO_x and NO_x emission; reduces coking, reduces high/low temperature corrosion; reduces coal calorie loss, prevents spontaneous combustion during storage; and other benefits.

Composition of SuperSaver environmental-coal additives

Components
Nano enzymes group Microelement coenzymes Activator

Appearance	Light yellow transparent liquid
Density	Approximately 1.02kg/l
Viscosity	Below 10cps

Product Summary

Biological enzyme groups can be direct applied to coal by sprinklers or mixed with coal in tankers with coal water mixture (CWM) material. It can reduce pollutants and improve combustion efficiency.

Enhance coal oxygen content: Achieve complete combustion with lower amounts of air, reduce emission of nitrogen oxides and increase combustion efficiency.

Accelerated oxidation and rate of electron transfer: Complete combustion, lower emission of carbon monoxide and increased energy efficiency.

Gain extra water gas: Hydrogen and carbon monoxide are good, clean energy sources. Its use reduces emission of nitrogen compounds and improves the ignition properties.

Oxidation of unreacted coal: Utilizes coals effectively, reduces amount of unreacted coals and hydrocarbons.

Nano-bio-catalytic conversion: Conversion of oxysulfide to sulfate (SO_4^{2-}) under high temperature environment. It is safe for the environment and a good source of fertiliser. Reduces emission of sulfide oxides and prevents environmental pollution problems such as acid rain, salinity and corrosion.

Biocatalytic reaction: Complete combustion and reduction of slagging on furnace wall.

Functions of SuperSaver

- ✓ **Saving coal consumption ca. 3~15%**
- ✓ **Reduces air intake , reduces oxygen content of exhaust by about 25%**
- ✓ **Reduces carbon content in slag by 10~20%**
- ✓ **Reduces sulphur compounds (SO_X) by 30~60%**
- ✓ **Reduces nitrogen compounds (NO_X) by 15~30%**
- ✓ **Reduces sludge by 20~50%**
- ✓ **Increases sulphate salt in slag by 20~50%**
- ✓ **Reduces high/low temperature corrosion**
- ✓ **Reduces stack gas heat loss and increases furnace temperature by 50~200˚C**
- ✓ **Increases coal's fusion point, prevents furnace wall coking and improves heat transfer**
- ✓ **Ringelmann scale lower by 3 levels**
- ✓ **Prevents calorie losses and spontaneous combustion of coal during storage**

How it works?

Direct addition onto coal, the enzymes catalyses the conversion.

Cracking
Improved oxidizing and burning properties, improve coal quality

Rapid cracking of hydrocarbons
Particles burns more completely

Extra oxygen combined with coal
Coal burns synchronically inside and outside and more completely in furnace

Decomposition of impurities
Reduction of fouling and accumulation of coke in furnace.

Transformation
Formation of non-toxic sulfate salts base from sulphide components, reducing toxic emissions.

Lower exhaust fumes
Emission of fumes meets safety standards.

To constrain anaerobic bacteria in coal during storage
Methanobactcriaceae bacteria and sulphate-reducing bacteria (SRB) in coal will be restrained due to extra oxygen combined with coal.

Product Advantages

Dual catalytic processes (under ambient & furnace temperatures)

Biological enzymatic catalyst at under room ambient temperature:

It usually takes ca.12~72 hours after application for the bio-catalytic-enzyme conversion process to reach maximum effect. The conversion includes modifying complex polymer high molecular structures in raw coals and enriching its oxygen content. Treated coal burns completely from both inside and outside under low excess air, minimizing the consumption of oxygen.

High quality coal can be converted with the bio-catalytic process to modify coal's oily volatile molecules to entrap the surrounding moisture and increase oxygenated molecules content, therefore substantially improving the performance, speed, synchronization and completeness of coal combustion.

The converted coal has a lower ignition point and there is an improvement in the efficiency of complete combustion in furnaces. Sulphurs in coal are converted to sulphate salt and the emission of harmful sulphur oxides is reduced.

The ash fusion temperature of coal is increased, which prevents slagging and maintains good heat transfer efficiency.

Extension of primary conversion for further thermal catalytic conversion:

Coal is enriched in oxygenated molecules after bio-catalytic modification using SuperSaver. It can achieve almost perfect complete combustion internally and externally under low excess air.

The bio-dispersant activity modifies the coals oily volatile molecules to entrap the surrounding moisture to form water gas at a high temperature of above 700˚C. Improvements in operational conditions gained by SuperSaver reduces air requirement of combustion (reduces oxygen content of exhaust by about 25%). The complete combustion process can still be carried out very well while minimizing stack gas heat loss. This increases the furnace temperature from 50˚C up to 200˚C and reduces formation of NO_X as well.

It removes the fouling due to accumulation of coke slag and maintains heat conduction at a high level. (Ameliorates formation of coke slag accumulation, further incinerates begrimed carbon deposits).

SuperSaver enables secondary advanced oxidation to fix sulphur in under the furnace temperature by lowering the energy barriers. With the application of SuperSaver, a sulfur fixing catalyst is formed in the coal. Under high temperatures during the burning process, enzymes and co-enzymes chemically react with sulfur to form sulfate. The stabilizers in the enzymes prevent the decomposition of sulfate and the inhibitors and organic stabilizers fix the sulfur. Sulfates are the safe end products formed by converting toxic intermediate sulfur oxide during the burning process and are then concentrated into the coal slags, which greatly reduces the sulfur oxide emission and avoids corrosion by emission of sulfur oxide.
(If SO_X combines with the water vapor H_2O that will form sulfuric acid H_2SO_4, i.e. acid rain.)

(The reduction of sulfate SO_X emission could also be determined by sampling the concentration of SO_4^{2-} in furnace sludge indirectly)

Protection of furnace and others benefits

1. The Bio-catalytic-enzyme helps in keeping the furnace and pipe walls clean by softening the fouling. This process in general takes approximately 15 days in cases of mild build up, and up to 45 days where there is a tough accumulation of coke. The loosened fouling is easily removed during the cleaning process. As a result, there is an increase in heat exchange and a reduction in outage reparation and maintenance costs.

2. Additives can convert complex heavy metals into metallic carboxylic acids, making furnace cleaning significantly easier. This also improves the energy efficiency of the furnace.

3. It reduces corrosion of exhausts and equipments due to a decrease in stress from temperature fluctuation. As a result, equipment lifespan is increased and maintenance costs are reduced.

Energy saving index by SuperSaver enzymes

- Excess residual exhaust air results in excess stack heat loss and increases the tendency of incomplete combustion if there is not enough inflow air.
  (The unreacted air might be approximately 6~10% for heavy fuel oil power generation boilers and 15% for industrial fuel oil boilers.)
- Exhaust temperature decreases by 3-5%
- Furnace wall temperature increases from 50˚C ~ 200˚C.
- Concentration of carbon monoxide emitted decreases by 60%~80% (CO is below 30 ppm and exhaust gas oxygen concentration is between 2~5%)
- Slag, uncombusted carbon and ash decreases by 30%.
- Reduction of emission of SO_X and NO_X: higher efficiency of burning.
- Increase of sulfate salt (SO_4^{2-}) in the slag.
- Injection preheat temperature of pulverized coal reduces by 10~20˚C
- Reduction in ash volume, density and weight.

Indications of effect

SuperSaver is safe for personnel who are in contact with it and does not cause damage to equipment. SuperSaver reduces the air intake requirement, improves the burning process and the efficiency of the furnace. The following are indications of SuperSaver working:

- Flames are brighter, furnace temperature rises and coal feeding speed is reduced.
- Reduction of intake air.
- Decrease in temperature of exhaust gas.
- Accumulated fouling is reduced.
- Reduction of unreacted coal and volume of ash.
- Reduction of sludge in terms of volume, density, granular size and change in colour.
- Increase in concentration of sulphate in furnace slag. (a function of sulphur conservation)
- Reduction of CO, NO_X and SO_X emissions and colour of smoke emissions will be visibly lighter.

The fouling will begin to decrease after 3~7 days of using SuperSaver. The remaining fouling will become porous but still remain on the furnace wall, pipelines and other parts of the system. Further reduction of fouling will occur over 45 days. The thermal resistance of coking will reduce further and will result in higher efficiency.

The exhaust temperature reduces by approximately 3~5%.

Reduction of unreacted oxygen in exhaust gas of approximately 50~70%.The enzyme increases the oxygen content in dry coal by 3.7 times which allow the combustion process to be carried out under low excess air environment. Normal exhaust requires approximately 6~8 % excess oxygen to support fully combust.

Comparison

SuperSaver Enzyme Coal Enhancer	Traditional Chemical Additives
. Environment-friendly Product . ● Can catalyze at both ambient temperature and high temperature. ● Twice the effect. Bio-enzyme at the nano scale has a catalytic rate thousands of times greater than any other kind. ● Catalyses at ambient temperature on coal site.	● With low catalytic conversion rate, only limited to harsh conditions like high temperature and pressure while in combustion chamber, and their effect doubtful, if any.
● It takes 12~72 hours to reach maximum conversion by the bio-catalytic-enzymes. The conversion process involves modifying complex high molecular structures in raw coal and enriching its oxygenates content. ● It improves the burning of coal molecules both internally and externally for a more complete combustion and reduces air intake. ● High quality coal can be converted by bio-catalytic process to modifying coal's oily volatile molecules to entrap surrounding moisture to increase oxygenates content, achieving a more complete combustion. ● Reduces sulphur content and converts sulphur to stable and safe sulfate. ● Lowers ignition point of coal (easier to burn) ● Increases ash fusion point of coal, preventing coke slag on furnace wall. ● Reuse coal sludge in the bottom of furnace, maximising fuel energy efficiency. ● Removes unpleasant odours, prevents coal calorie loss due to natural oxidation and spontaneous combustion. Suitable for all types of coal furnaces and coal mine stockpiles...etc.	● No such effect
● The Coal's oily volatile molecules entrap the surrounding moisture which is converted to water gas and provide more energy by bio-catalytic process in the furnace, therefore increasing the heat value. ● Complete combustion with reduction of oxygen content of exhaust by about 25%. Reduces stack gas heat loss and increases furnace temperature by 50~200˚C. ● Converts SO、SO_2、SO_3 to sulphate, preventing formation of detrimental sulfuric acid. ● Increase ash fusion point, preventing furnace wall slagging and improving heat transfer.	● Unable reduce intake air flow rate, unable to reduce stack heat loss and unable to reduce nitrogen oxides emission. ● Increase in surface catalytic activity, possibly causes corrosion due to high temperature and aggravates fouling. ● Action due to emulsification from high molecular additives, favours formation of coal with high levels of moisture and low oxophilicity, it could on the contrary run out of oxygen from coal, causing formation of dark smoke.
● Saves coal by up to 3-15% by combining above advantages and depending on the type of furnace. ● Increase in concentration of sulfate in sludge; reduction of sulphur compounds toxic SO_X emission by 30~60%. ● Reduction of nitrogen compound NO_X emission by 15~30% ● Ringelmann scale lower by 3 levels. ● Reduces formation of ash dramatically ● Prevents corrosion due to high temperature, extends the lifespan of furnaces.	● Most traditional additives provide only a single benefit and you have to use a range of different products to achieve a total solution. ● Most chemical techniques are inefficient and are not cost effective.

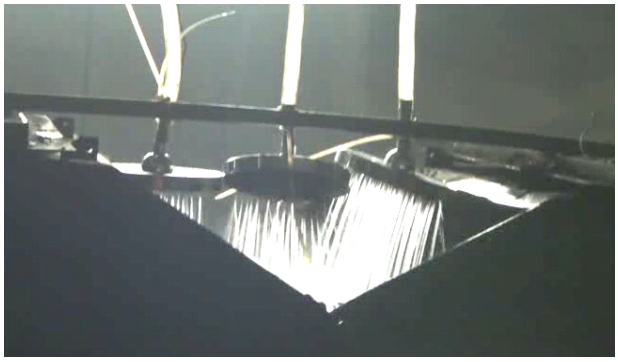
Instructions of applying SuperSaver coal enhancer

Standard dosage: 1:10000, one tonne of coal additive for every ten thousand tonnes of raw coal. Dilute additive solution with water to a ratio of 1:50~100 and spray evenly on coal. The concentration depends on the moisture content in coal. (The moisture content will be raised by 1~2 % after application)

Package: Barrel or shipped by tanker.

Application Method 1

Use rotary drum mixer or sprinklers to spray solution from above conveyor belt on site. (Refer to picture below).



Note

The amount of SuperSaver should be adjusted higher for first application for better results, especially if the furnace has high levels of fouling or has not been recently cleaned.

1. SuperSaver must be kept away from sunlight or UV light.
1. For maximum efficiency, the application of SuperSaver must be applied to all coal components.
2. SuperSaver must be applied to coals at least 12~72 hours prior to use. It will last up to 6 months.

Application Method 2

Coal additive can be added to raw coal before delivery from mining site. For example, spray the SuperSaver at transition depot or harbor during transportation. SuperSaver can be applied on coals before storage, it exhibits excellent effects even months later.

Properties of SuperSaver enzyme additive

Nano Bio Enzyme Groups/Trace Element Co-Enzymes/Ammonium Acetate

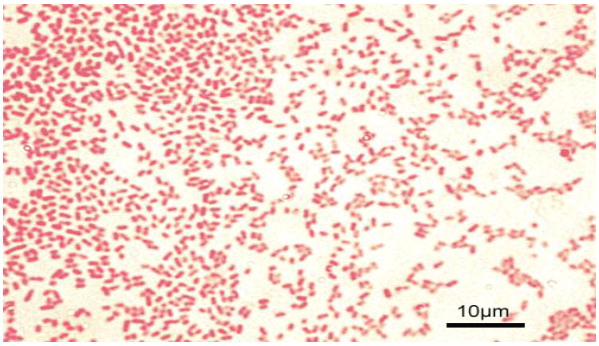
Physical Properties

After spraying SuperSaver, the solution penetrates into the coals. After only a few hours, the bio-enzyme and gene triggering process will initiate. The specific biochemical reaction improves oxygenates content of the coal, making it become a more environmentally friendly fuel.

The coal after the biological enzymes catalytic burn more efficiently, maintains stable and synchronized ignition of the combustion oxidation chemical reaction rate, while improves furnace flames and stabilise the fluctuating flames.

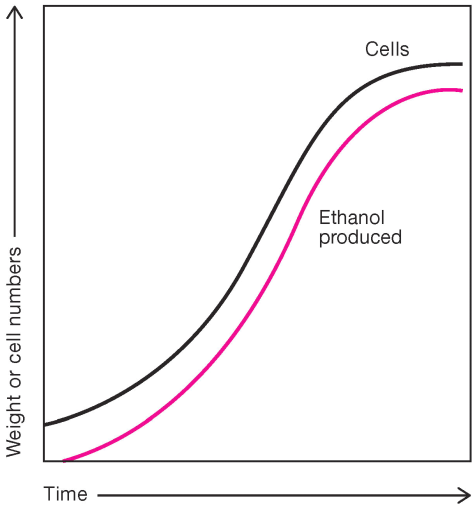
The formation of water gas (carbon monoxide and hydrogen) lowers ignition point to 200˚C (standard coal ignition normally begins at 300˚C). Catalytic activity continues aggressively until it reaches 700˚C. During the burning process, oxygen-enriched oxygenates and high energy free radicals are released causing the coal molecules to break down and reduce in size and maximising the surface area and oxygen affinity. This promotes synchronous ignition, stable high temperature combustion, resulting in improved boiler efficiency and coal savings.

Micro-organisms

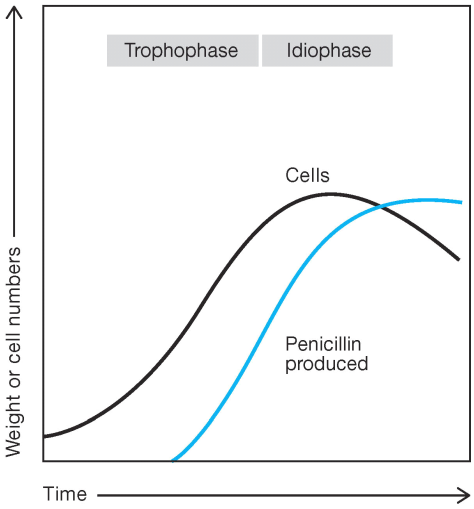


Microscopic image (Gram staining, magnification:1,000)
Bacteria: 1 ~ 4 μm

Primary and Secondary Microbial Metabolites



A primary metabolite, such as ethanol from yeast, has a production curve that lags only slightly behind the line showing cell growth.



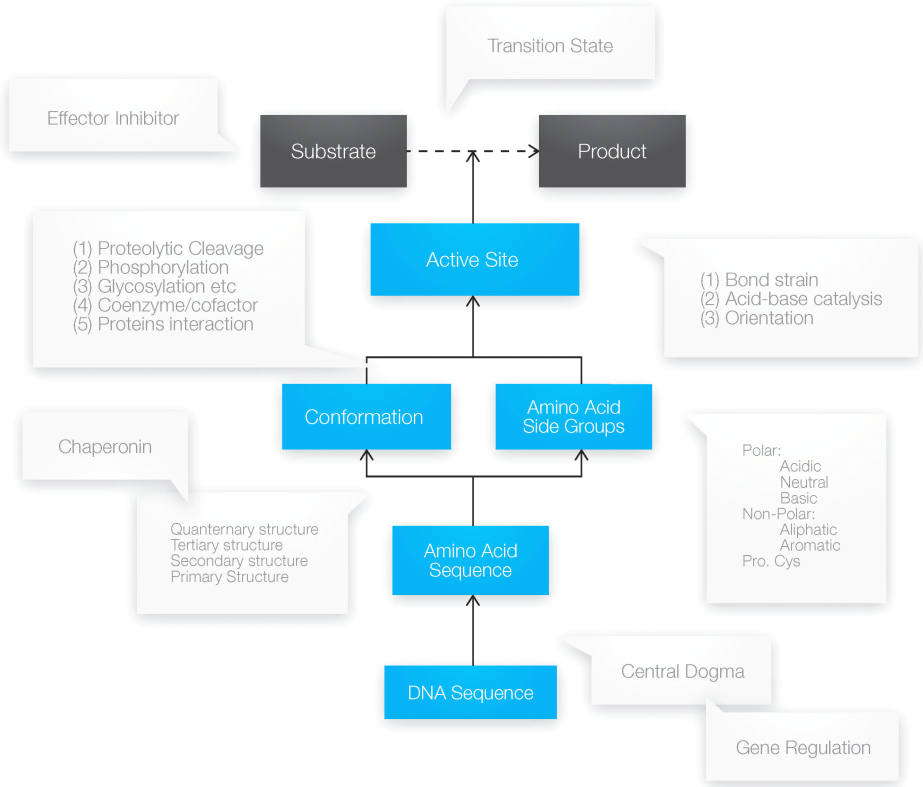
A secondary metabolite, such as penicillin from mold, begins to be produced only after the logarithmic grown phase of the cell (trophophase) is completed. The main production of the secondary metabolite occurs during the stationary phase of cell growth (idiophase).

Characteristic of Enzymes

The Chemical Nature of Enzyme Catalysis

The enzyme's catalytic activity rapidly converts the reactants to a resultants matrix and the enzyme itself is not consumed during the reaction.

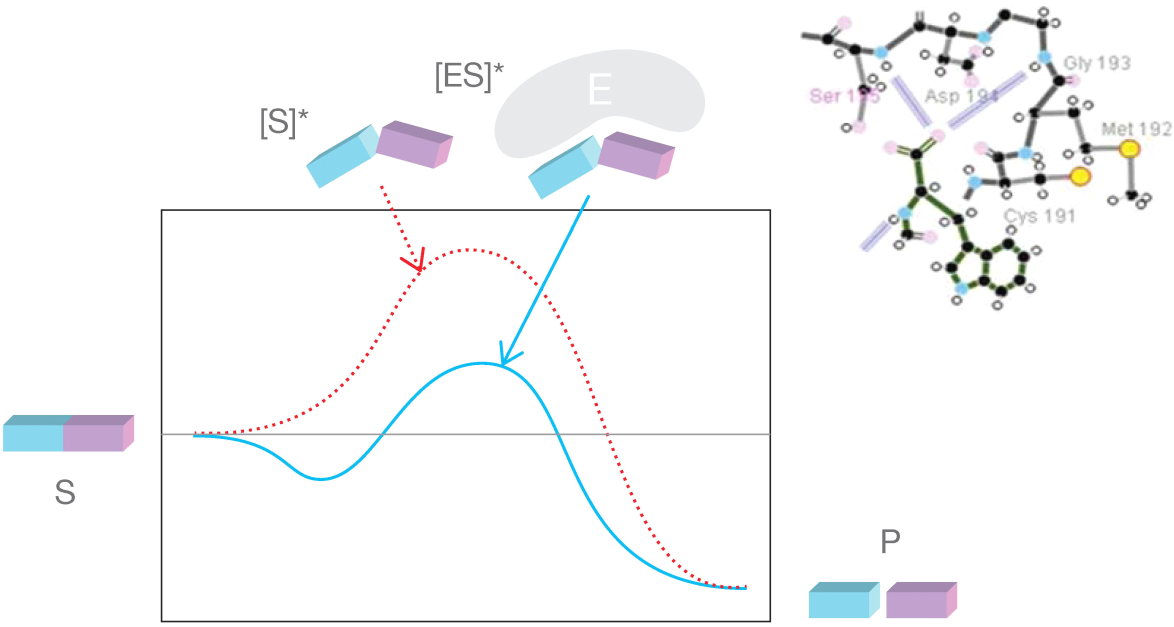
The active site in the enzyme allows such conversion capabilities, the selective active site only functions for a specific reactant, and remaining stable through the transition state.



Interaction Forces

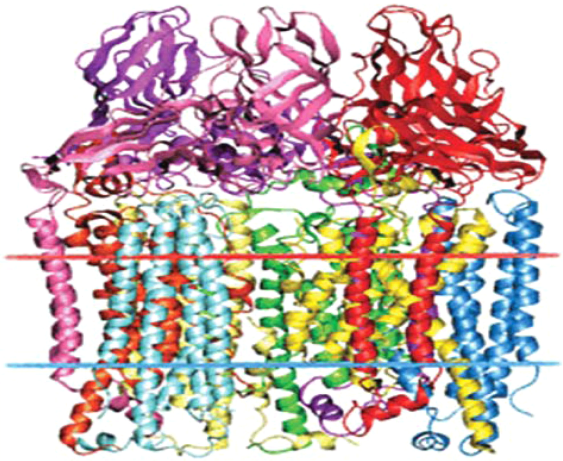
Enzyme Catalysis

Enzyme Catalysis



By providing an alternative reaction route and by stabilizing the intermediate state, the enzyme reduces the energy barrier required to reach the highest energy transition state of the reaction. The reduction of activation energy endows the number of reactant molecules with enough energy to reach the activation energy and complete oxidative reaction.

Particule Methane Mono Oxygenase

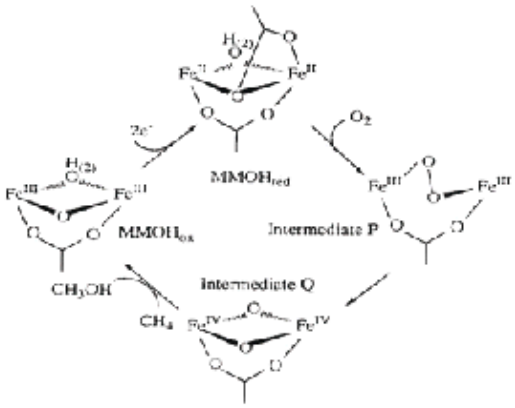


$$CH_4 + O_2 + NAD(P)H + H^+ \rightarrow CH_3OH + NAD(P)^+ + H_2O$$

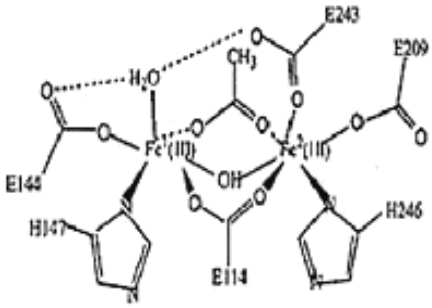
Methane Mono Oxygenase (MMO)

- An enzyme capable of oxidizing the C-H bond in methane as well as other alkanes.
- The diiron site of methane monooxygenase (MMO) has the unique ability to activate methane. The substrate activation is best described by an almost pure hydrogen abstraction step, followed by the formation of a metal-carbon bond.
- The particulate methane monooxygenase and related ammonia monooxygenase are integral membrane proteins, occurring in methanotrophs and ammonia oxidisers, respectively, which are thought to be related.
- Methylobacterium sp. strain CRL-26 grown in a ferment or contained methane monooxygenase activity in soluble fractions.
- Soluble methane monooxygenase catalyzed the epoxidation / hydroxylation of a variety of hydrocarbons, including terminal alkenes, internal alkenes, substituted alkenes, branched-chain alkenes, alkanes (C1 to C8), substituted alkanes, branched-chain alkanes, carbon monoxide, ethers, and cyclic and aromatic compounds.
- The optimum pH and temperature for the epoxidation of propylene by soluble methane monooxygenase were found to be 7.0 and 40°C, respectively.
- Among various compounds tested, only NADH2 or NADPH2 could act as an electron donor. Formate and NAD+ (in the presence of formate dehydrogenase contained in the soluble fraction) or 2-butanol in the presence of NAD+ and secondary alcohol dehydrogenase generated the NADH2 required for the methane monooxygenase.
- Epoxidation of propylene catalyzed by methane monooxygenase was not inhibited by a range of potential inhibitors, including metal-chelating compounds and potassium cyanide. Sulfhydryl agents and acriflavine inhibited monooxygenase activity.
- Soluble methane monooxygenase was resolved into three components by ion-exchange chromatography. All three components are required for the epoxidation and hydroxylation reactions.

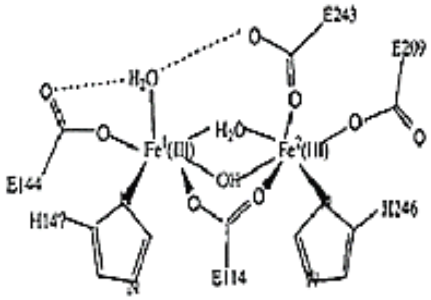
Catalytic Cycle for MMO (proposed)



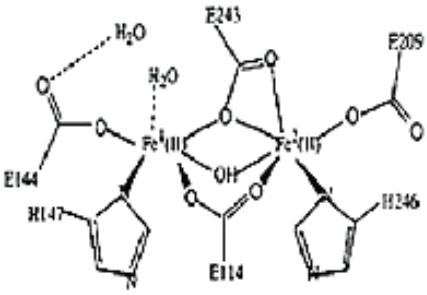
MMOs Diiron core (Resting、Oxidized & Reduced State)



MMOH$_{ox}$ - M. capsulatus (4˚C)



MMOH$_{ox}$ - M. trichosporium (-18˚C)
- M. capsulatus (-160˚C)



MMOH$_{red}$ - M. capsulatus (-160˚C)

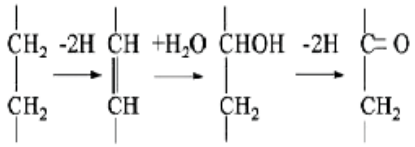
Principles of supporting combustion

The burning process releases a large amount of active oxygen components at 180˚C after the addition of SuperSaver. The oxygen components contribute to the burning process, enhancing the burning rate and saving coal. The SuperSaver additive improves the ignition properties and burning rate by over 10~15% while reacting with ash at high temperature. There is interaction of oxygen, coal molecules and transfer of electrons with the presence of biological components under high temperature environments. It catalyses the burning process and solidifies fixes the sulphur components. SuperSaver lowers the coal ignition temperature, improves the rate of burning and reduces the amount of unreacted coal.

Reduction of long coal carbon chain by biocracking

The bigger and longer the coal carbon chain, the harder it is to burn and with lower efficiency. After applying our enzyme enhancer, the cracking process reduces the molecular size and improves the burning efficiency. Keto acids and intermediates which react with compounds inside cells are investigated comprehensively in biology. Unlike ordinary oxidation where oxygen directly reacts with carbon and hydrogen atoms to produce carbon dioxide and water, the specified oxidation process is through dehydrogenation with small amounts of reactions directly interacting with substrates. The produced hydrogen can remain in oxidative phosphorylation while transferring electrons. The final product is water.

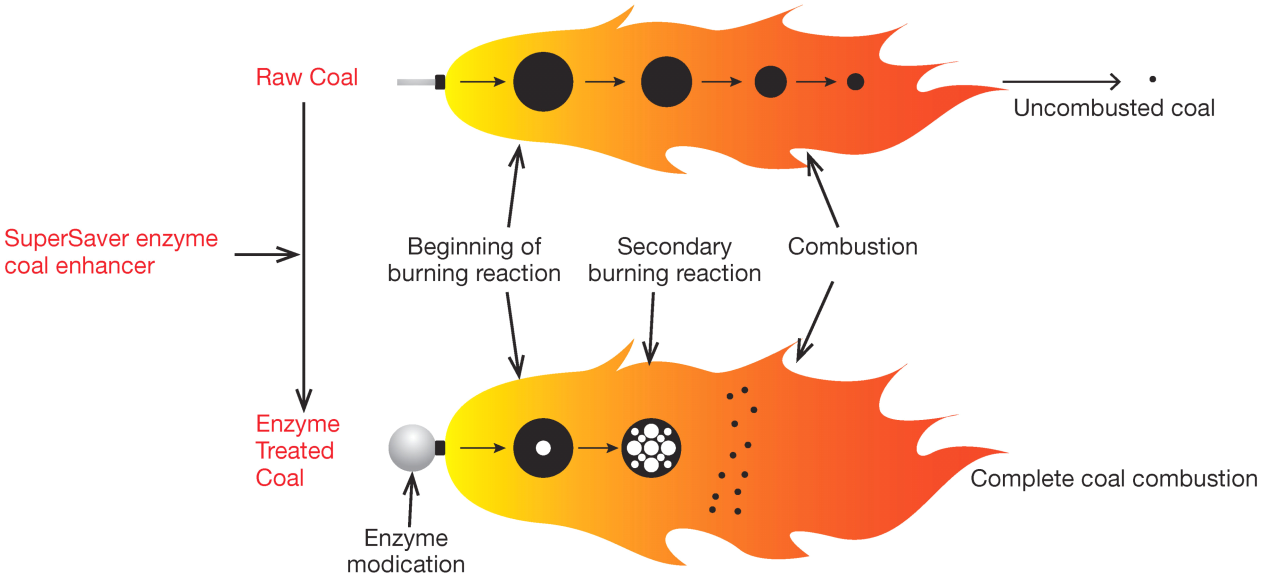
A keto functional group is formed by reactions like hydrolysis. De-hydrogenation is commonly found in the tricarboxylic acid cycle (TCA cycle) and metabolism of lipids. Such a functional group can further transform into other functional groups.



Improvement of micro-combustion

With the application of SuperSaver, a sulfur fixing catalyst is formed in the coal. Under high temperatures during the burning process, enzymes and co-enzymes chemically react with sulfur to form sulfate. The stabilizers in the enzymes prevent the decomposition of sulfate and the inhibitors and organic stabilizers fix the sulfur.

SuperSaver contains biological active ingredients that modify the coal so that under high temperature, it will actively and rapidly react, forming amorphous crystal micro-explosions within that break down the coal on a molecular level. This helps to achieve complete and more efficient combustion.



Reduction of dust and improvements to combustion

Complete combustion, with the increase the amount of active oxygen atoms, reduces the formation of carbon monoxide and reduces emissions. It also reduces the amount of combustible dust and slag content in the furnace. The SuperSaver reduces the amount of residual coal, slag and ash and their particle size. It increases the coal burning surface area, improves efficiency of combustion and reduces consumption of fuel by 3~15%.

Principles of improving energy efficiency with SuperSaver

The burning process releases a large amount of active oxygen components at 180˚C after the addition of SuperSaver. The oxygen components contribute to the burning process, enhancing the burning rate and saving coal. The SuperSaver additive improves the ignition properties and burning rate by over 10~15% while reacting with ash at high temperature. There is interaction of oxygen, coal molecules and transfer of electrons with the presence of biological components under high temperature environments. It catalyses the burning process and solidifies fixes the sulphur components. SuperSaver lowers the coal ignition temperature, improves the rate of burning and reduces the amount of unreacted coal.

Improves energy efficiency

Excellent microdispersion

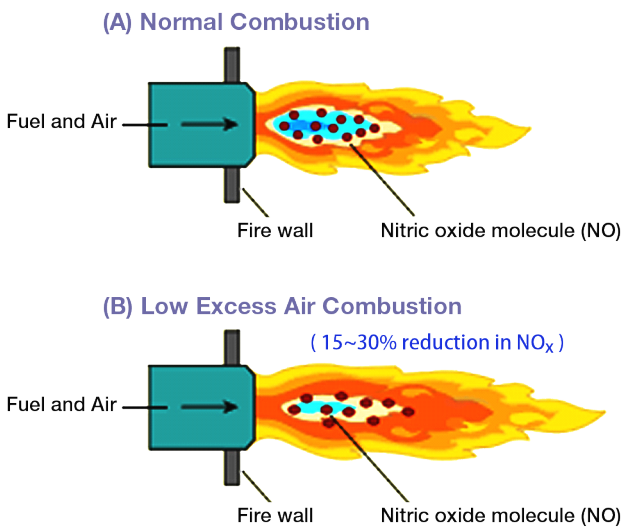
- The biocracking process breaks the coal hydrocarbon bonds and decomposes hydrocarbon and sulphur compounds. They rapidly decompose to fine particle molecules which burn more effectively and improve efficiency.
- Dispersed coal molecules – improves flammability and is environmentally friendly.
- Energy-saving – increased coal injection, enhances complete combustion and energy efficiency.
- Approximately coal saving rate ca. 3~15%

Passivate reactivity of heavy metals and reduction of toxic emissions

- Ameliorate high temperature corrosion: Heavy metals form microdispersed ionic salts complex. Reduction of slagging and minimization of high temperature corrosion by increase furnace temperature.
- **Improved emission:** Decreased activity reduction of SO_X and NO_X compounds emissions are due to complete combustion under low excess air, further convert endeavour to make Sulphide sulphur and nitrogen oxides …etc. Toxic elements in coal are converted to safe saturated base compounds. Reduces sulfur oxides, nitrogen oxides, malodor and black smoke emission.

Complete combustion with low excess air

- The catalytic process causes coal particles to be surrounded with oxygen molecules. It reduces the ignition point and provides extra free oxygen to improve combustion. It reduces the demand for oxygen, maintains energy supply and lowers stack heat loss.
- Reduces nitrogen compounds (NO_X) by 15~30%



How to reduce nitrogen and sulfide oxides?

Reduction of nitrogen oxide components with SuperSaver

Nitrogen is found in abundance and makes up 78% of the atmosphere. Nitrogen is a major component of NO_X. The NO_X is formed under combustion conditions at temperatures above 700°C, and a small portion of the nitrogen oxide is from nitrogen compounds in the oily molecules of the coal itself, the use of biocatalysts can stabilise the oxidized nitrogen compounds.

$$N\text{-}3H_3 \rightarrow N+2O \rightarrow N+4O_2 \rightarrow (N+5O_{3\text{-}1})$$

NO_X refers to NO, NO_2 and other general forms of nitrogen compounds. It is classified in the category of environmental exogenous hormones. They are found to cause many detrimental health effects when consumed or absorbed into the body of human beings.
Completely oxidized nitrogen compounds are inert and are not listed in the restricted chemical list. The enzymes catalyst improves the burning efficiency by breaking down the molecular size and minimizes the consumption of oxygen from air. The consequence of this is a reduction in the release of NO_X into the air.

Reduction of sulphide oxide components with SuperSaver

The process of the coal combustion in the furnace, Sodium sulphate and solid calcium sulphate are formed by oxidation of sulphur dioxide with sodium and calcium ions from SuperSaver, which reduces the emission of sulphur oxides. The desulfurization is the direct reaction of SuperSaver with sulphur oxides and formation of stabilized sulfate which reduce toxic sulphur oxide emission by up to 30~60%.

Sulphur compounds are commonly found in carbon based fuels such as natural coals and fossil fuels. Sulphur is oxidized into very stable form SO_4^{-2} after enzymes treatment and furnace oxidization. Desulfurization of coal can reduce the emission of SO_X into the environment.

$$H_2S\text{-}_2 \rightarrow S0 \rightarrow S+2O \rightarrow S+4O_2 \rightarrow S+6O_3 \rightarrow (S+6O_{4\text{-}2})$$

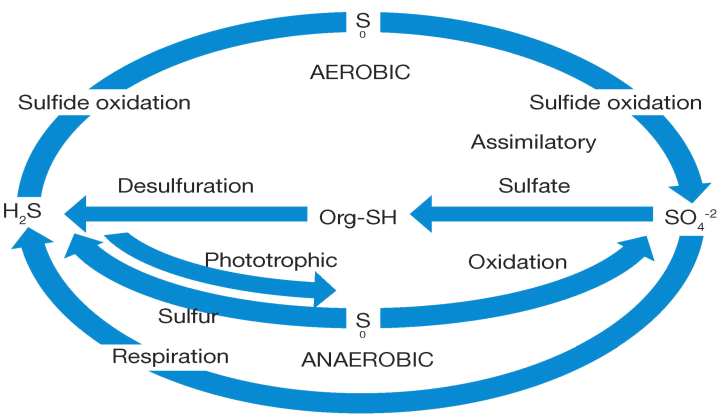
"**Bio-desulfurization**" is a general term for the technology. It can be called "**bio-catalytic-sulphur-transformation**". It uses catalytic enzymes to reduce toxic sulphur compound to stable non-toxic sulfate (SO_4^{-2}).

$$H_2S^{-2} \rightarrow S^0 \rightarrow S^{+2}O \rightarrow S^{+4}O_2 \rightarrow S^{+6}O_3 \rightarrow (S^{+6}O_4^{-2})$$

SO_X refers to compounds such as SO, SO_2, SO_3 and other sulphur compounds. These sulphur compounds are major contributors to acid rain and harmful to the environment. It is released into the air after combustion and corrosive with moisture in air. Sulphate (SO_4^{-2}) is fully stable after complete oxidation, harmless to the environment and is also useful as nutritional fertiliser.

Principles of biological desulfurization

The biological desulfurization process is based on natural organic micro-organisms that can remove organic substances, combine sulfur and help maintain heat content. Biological enzymes can crack the bonds between carbon to carbon (c-c) and carbon to sulphur (c-s) and produce oxygen, carbon, hydrogen compounds and sulphate by-products etc. The desulfurization process is achieved by the catalytic process between bacteria. The biological enzyme catalysts do not form any toxic byproducts or side reactions.



Principles of preventing corrosion

Corrosion is a major cause of plant outage and increases operating costs. It is caused by the presence of V_2O_5 under high temperature conditions (**high temperature corrosion**); **low temperature corrosion** is due to the conversion of sulphur dioxide to sulphur trioxide, causing sulphuric acid to form while reacting with steam in furnace. V_2O_5 is an ideal catalyst for oxidation of sulphur dioxide. Formation of V_2O_5 can be reduced by the organic compounds present in SuperSaver. It reduces the damage caused by V_2O_5 and reduces the corrosion due to both high and low temperatures.

High temperature corrosion is caused by the presence of sodium (Na), sulphur (S), vanadium (V) and potassium (K) in a high temperature furnace. They damage the turbine blades, combustion chamber and spray nozzle. They form products such as V_2O_5 (has melting point of 690˚C), Na_2SO_4 (melting point 884˚C) and aggravate the corrosion process.

Na_2SO_4 crystallizes when the partial pressure is saturated in steam vapour on the surface of metal. It starts to corrode the surface when they interact with Cr_2O_5 to become $Na_2SO_4 \cdot Cr_2O_3$. The low melting point compound ($Na_2SO_4 \cdot Cr_2O_3$) causes corrosion. High temperature occurs when the concentration of vanadium is greater than 0.5 ppm in coal.

Corrosion due to high temperature is traditionally prevented by the addition of magnesium sulphate,

$MgSO_4 \rightarrow MgO + SO_3$

Mg has strong corrosion protection properties and reduces rate of fouling.

3Mg + V2O5 → Mg3V2O8 (mp.1191˚C)

It can form $Mg_3V_2O_8$ with a high melting point (mp.1191˚C) which prevents corrosion. Vanadium and vanadium sulphate compounds ($VaSO_4$) are easily removed in furnace. Magnesium has the ability to reduce oxidation of sulphur dioxide; therefore magnesium reduces the formation of sodium sulphate.

Prevention of corrosion with SuperSaver

SuperSaver microdisperses sulphur, nitrogen and phosphorus compounds. Sulphur is converted to Sulphate (nitrate ions and compounds which reduces the amount of SO_2 and SO_3.

(decreased low temperature corrosion)

Salts like sodium chloride form Na_2SO_4 and are suspended in combustion chambers and exhausts. Sulphate forms Mg_3SO_4 、 $7H_2O$ and other similar products, forms with barium (Ba) and reacts further with V_2O_5 to form $Mg_3V_2O_8$ (mp.1191°C). Enzyme prevents those detrimental substances to agglomerate and molten under high temperature corrosion by keeping in solid inert ash, making them bulky and easy to clean up from the furnace chamber.

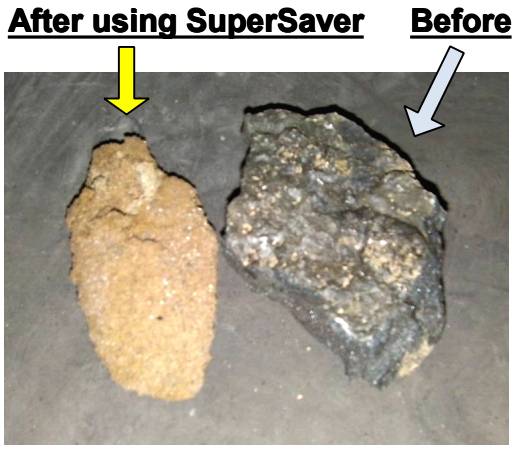
(decreased high temperature corrosion)

Corrosion inhibitors in SuperSaver enhance the ash fusion point and cause the ash to remain solid during the combustion process. It reduces slag and renders fouling on furnace surfaces more brittle loosen and easy to clean up.

Principle of reducing foul, coke and slag

Reduction of fouling and coke with SuperSaver

The presence of extra active oxygen formation by SuperSaver under the high temperature reactivates and re-burns the residual coal and the coke accumulated on combustion chamber. The surface reduces the adhesive strength due to a higher pH environment (pH = 8.5), which allows the accumulated fouling/coke to separate, resulting in a cleaner combustion chamber and heat exchanger. The SuperSaver loosen and remove carbon deposits under high temperature (1100˚C) and leaves behind a dry, solid film on the furnace wall, and it could prevent the furnace wall damaged from further corrosion.



Reduction of slagging with SuperSaver

Carbon deposits reduce the lifespan and output of equipment, affecting not only heat transfer, but also seals, air flow, burner nozzle and emissions.

SuperSaver through microdispersion molecules process, improves coal combustion and feed conditions, and reduces of carbon deposits in the furnace. It forms a protective layer that protects burner nozzles and metal surface. The advanced biocleaning formula cleans up the nozzle, combustion chamber and exhaust system.

Cleaning effect and others benefits

- Reduces the accumulation of carbon deposits, provides a smooth feeding process and reduces number of shut downs per annum.
- Peeling of fouling from combustion chamber and heat exchanger, recovers lost heat transfer rate in furnace, exhaust and pipe lines in the system.
- Gradual removal and prevention coal stockpile formation of undesirable anaerobic microorganisms, prevents coal calorie loss and spontaneous combustion, reduces natural oxidation and energy loss.
- Heavy metal impurities microdispersed to form complex soft ionic salts and reduces the need for maintenance and cleaning.
- Cleans mechanical parts and carbon deposits in the system, recovers firing power and reduces toxic emission.
- Reduces damage due to corrosion and lowers maintenance costs.

Principle of prevention calorie losses and spontaneous combustion of coal with SuperSaver

Causes of calorie losses and spontaneous combustion of coal during storage

Coal is generally composed of both organic and inorganic components. The content of coal is primarily, carbon, which comprises its combustible elements (about 65% to 95%); hydrogen (approximately 1% to 2%); oxygen (approximately 3% to 5%, and sometimes up to 25%); and sulphur (approximately 10%). The combination of the contents of coal is referred to as burnable materials, which will determine its combustibility. In addition, coal also contains a number of non-combustible content such as mineral ash (5% to 15%, can be up to 50%) and water (usually 2% to 20%), these being referred to as inert materials.

Generally coal in storage stockpiles in natural environment conditions has a minimum of 16% loss in calories within 3 months (depending on coal specification/origin, temperature of storage, humidity, sun exposure, ventilation and other factors). Mainly there are three causes as follows:

(1) The natural oxidation of coal

At the outer layers of coal stockpile closer to air will be oxidized and to produce combustible substances such as CO, CH_4 and other alkane compounds. During oxidation, there is rapid and intense generation of heat, and if the heat could not be dissipated from the stockpiles, it will turn to create a chain reaction that accelerates further oxidation and heat in coal and eventually leads coal to spontaneous combustion.

(2) Calories of coal consumed by anaerobic Methanobactcriaceae bacteria

Many micro-organisms which originally lie dormant in coal beneath the earth will become active upon excavation. At the bottom of coal stockpiles, the anaerobic Methanobactcriaceae bacteria could grow rapidly because of the condition of lack of oxygen. They will consume coal's calories to generate lots of methane (CH_4) escape from coal stockpile inside out. Methane is a kind of extremely flammable gas; it will further improve the risk of spontaneous combustion, and cause the calorie losses of coal.

(3) Heat generated and accumulated during the process of forming sulfuric acid

Sulfate-reducing bacteria (SRB) in coal will reduce sulphate to sulphur. When sulphur meets water and oxygen which are naturally found in coal, a chemical reaction occurs to form sulphuric acid (H_2SO_4) and also results in the releases of heat. The increased heat accelerates the reactions of forming H_2SO_4 and results in rapid heat accumulation. Spontaneous combustion of coal will occur once temperature has reached a certain level and obtained adequate air.

Higher levels of the sulfur content of coal will result in a greater loss of calories due to sulfate-reducing bacteria (SRB) breeding during storage.

Principle of prevention calorie losses and spontaneous combustion of coal during storage

SuperSaver coal enzymes could create a catalytic modification to coal's molecular structure and break down the H_2O contained in coal where molecular H will be combined to form other substances, and molecular O will be added to coal's molecular structure. With the extra oxygen combined with coal, brings the result the anaerobic Methanobactcriaceae bacteria and sulphate-reducing bacteria (SRB) will be restrained. In addition, it will cause the coal burned synchronically inside and outside and more completely in furnace. Thus SuperSaver coal enhancer could preserve calorie losses and spontaneous combustion of coal during storage, and promote its combustibility in furnace.

Analysis of Coal

1) Analysis of Coal by Shanxi Jiexiu Xinhe Minerals Quality Testing Co., Ltd.

介休市鑫河矿产品质量检测有限公司检验报告单

送样单位：蓝海生技国际贸易（天津）有限公司

	编号	序号	名称	浮沉分析 含煤%	浮沉分析 含中煤%	浮沉分析 含矸%	工业分析 全水 M_t%	内水 M_{ad}%	灰分 A_{ad}%	挥发分 V_{ad}%	焦渣 CRC	固定碳 FC_{ad}%	粘结指数 G_{R1}	胶质层 Y mm	胶质层 X mm	胶质层 曲线型	自由膨胀序数 FSI	发热量 弹筒 $Q_{b,ad}$	发热量 高位 $Q_{gr,d}$	发热量 低位 $Q_{net,V,ar}$	元素分析 硫 $S_{t,ad}$%	元素分析 氢 H_{ad}%
A2, with SuperSaver	中有	090910/14	中煤				3.91	1.26		16.78								5068	5094	4726	1.43	3.07
A1, without SuperSaver	无中	090910/15	原煤				2.45	1.18		16.54								5138	5154	4864	1.71	3.10
B1, without SuperSaver	煤元	090910/16	原煤				3.28	0.93		14.03								6820	6785	6372	3.88	3.58
B2, with SuperSaver	煤有	090910/17	原煤				2.79	0.89		14.40								6559	6542	6176	2.88	3.48

说　明

1.中煤添加前后：硫份含量为1.71%，降到1.43%，降硫效果16.4%。

2.原煤添加前后：硫份含量为3.88%，降到2.88%，降硫效果25.8%。

批准：　　审核：杨林青　　化验员：张　李　　2009 年 09 月 10 日

Name of product: **SuperSaver Coal Enhancer**　　Purpose of test: **To examine the effect of SuperSaver on coal**

(A) Before and after use of SuperSaver for refined coal:
Sulfur content was 1.71%. After SuperSaver, sulphur content was reduced to 1.43%, a reduction of 16. 4%.

(B) Before and after use of SuperSaver for raw coal:
Sulfur content was 3.88%. After SuperSaver, sulphur content was reduced to 2.88%, a reduction of 25.8%.

By regulation, a penalty of 10 RMB per every 0.1% over 1% of sulphur content.

1. The first batch contained 1.71% sulfur. A reduction of sulfur by 0.28% using SuperSaver produced a saving of 28 RMB.
2. The second batch contained 3.88% sulfur. A reduction of sulfur by 1% using SuperSaver produced a saving of 100 RMB.

There is also the added benefit of a reduction of fouling/coke, which in turn lowers maintenance costs in the long run.

2) Analysis of Coal by China Coal Research Institute (Beijing)

煤炭科学研究总院北京煤化工研究分院
Beijing Research Institute of Coal Chemistry
China Coal Research Institute
煤炭分析报告
Analysis of coal
（本报告只适用于来样）
（The data sheet is only responsible for the received sample）

报告日期 Report Date　2009-9-28

送样单位 Report to　永丰环能科技

实验室编号 Lab.No.	来样编号 Sample No	工业分析 Proximate Analysis M_{ad}%	A_{ad}%	A_d%	V_{ad}%	V_d%	V_{daf}%	FC_d%	CRC	着火温度 ℃ Ignition temperature 原样 Raw	氧化 Oxidation
09-691	无添加剂煤样	5.65	14.69	15.57	28.15	29.84	35.34	54.59	2	341	309
09-692	有添加剂煤样	4.70	15.19	15.94	28.12	29.51	35.10	54.55	2	328	306

实验室编号 Lab.No.	来样编号 Sample No	元素分析 Ultimate analysis % C_{ad}	C_d	H_{ad}	H_d	N_{ad}	N_d	O_{ad}	O_d	$S_{t,ad}$ %	$S_{t,d}$ %	$Q_{gr,ad}$ MJ/Kg	$Q_{gr,ad}$ cal/g	$Q_{gr,d}$ MJ/Kg	$Q_{gr,d}$ cal/g
09-691	无添加剂煤样	64.65	68.52	3.62	3.84	0.82	0.87	9.76	10.34	0.81	0.86	25.48	6093	27.01	6459
09-692	有添加剂煤样	64.96	68.16	3.76	3.95	0.93	0.98	9.71	10.18	0.75	0.79	25.63	6129	26.89	6431

（只对来样负责）

审核 Checked by　　批准 Approved by

Name of additive: SuperSaver Coal Enhancer

Ignition temperature:
After the addition of SuperSaver, the ignition temperature lowered from 341°C down to 328°C, reduction of 13°C.

Sulfur content:
St,ad : Sulfur is reduced from 0.81% down to 0.75%,a reduction of 7.4%.
St, d : Sulfur is reduced from 0.86% down to 0.79%, a reduction of 8.1%.

Effects:
1. Reduction of sulfur in coal, lower emission of sulfur dioxide.
2. Reduction of flash point, easier to burn.
3. Reduces fouling/coke and cuts back maintenance costs.

Assessment

Chain Grate Boiler

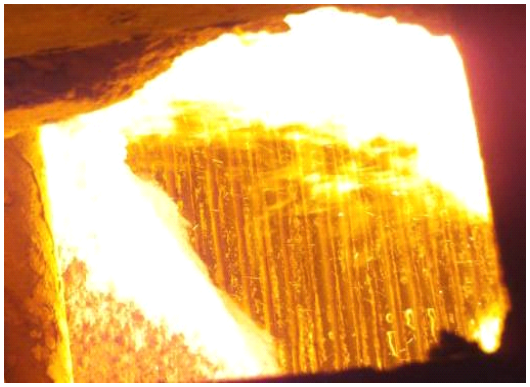
Sulphur Content: Analysis of Coal showed the use of SuperSaver produced a 16% reduction of sulphur.

Emission of sulfur dioxide: Reduced by 86.2%

Consumption of coal: Reduction of 14.7%

Amount of ash produced: Reduced by more than 50%, reduction of unreacted coal.

Fouling after use of SuperSaver: Accumulated fouling and coke removed, lowered cost of maintenance.



After addition of SuperSaver

Reduction of fouling and coke in furnace piping to enhance its efficiency of heat exchanging, besides, the temperature in combustion chamber is increased due to the coal burns synchronically inside and outside and more completely. This resulted in higher output and fuel saving.

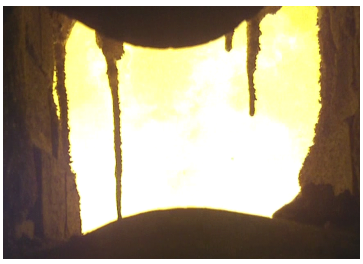
Before adding SuperSaver

There was heavy fouling and coke accumulated on furnace piping. Red and black flames were visible, showing that coal hadn't burnt effectively. The temperature within the furnace was low, resulting in low efficiency.

Coke melted and fell down

After the addition of SuperSaver on coal, within one week we observed that accumulated fouling and coke starting to melt and fall down. The reason for this is due to the SuperSaver also causing changes to the coke, **decreasing its melting point**.

In addition, significant amounts of the **unburned carbon** that usually remains in the coke (without the use of SuperSaver), **will now be burned**.



Slag and ashes after used SuperSaver

Coke became brittle and more easily removed. Slag appeared yellow and white crystals formed.

Coal burned completely, fouling and coke fell into the slag, and ash was significantly reduced.