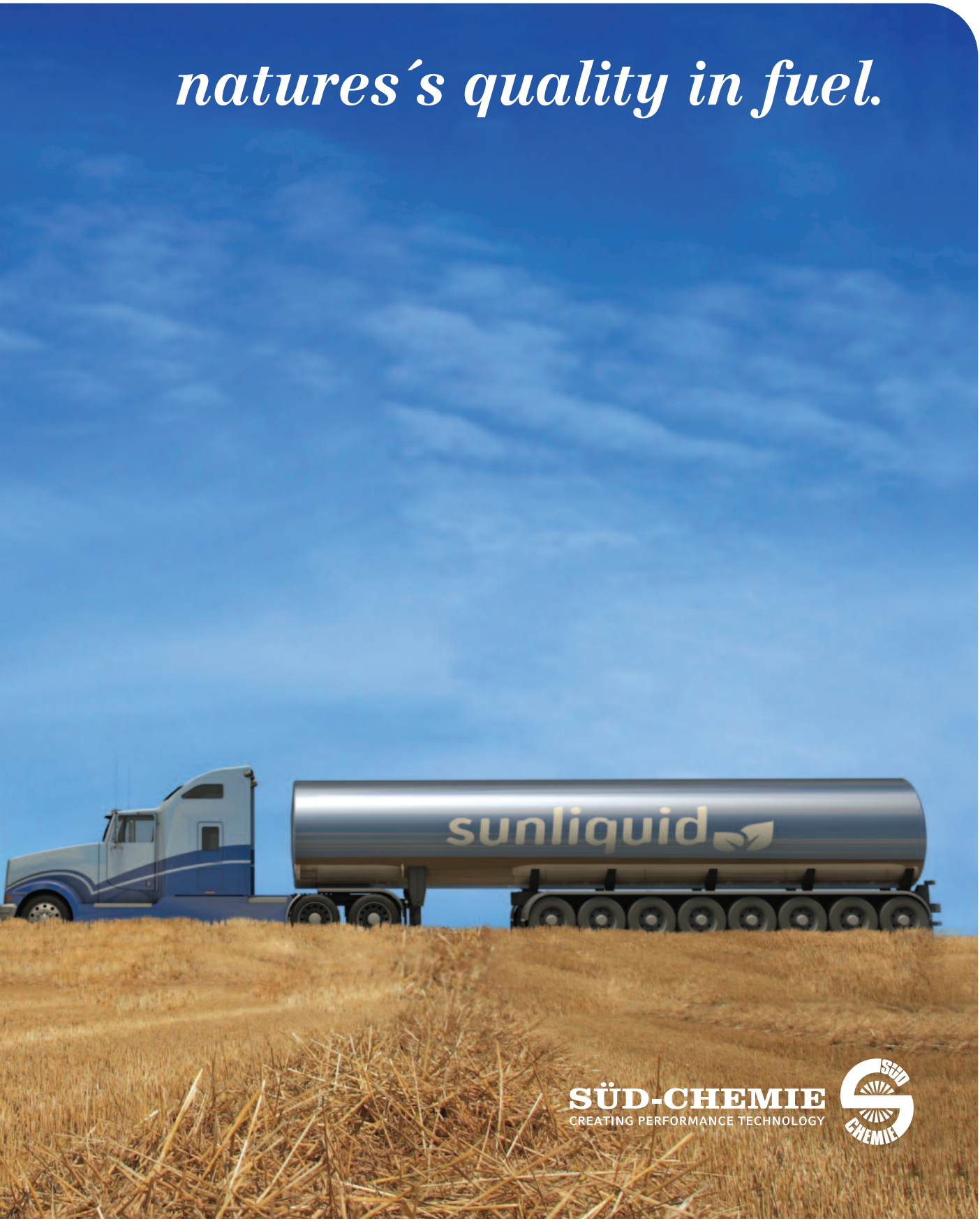
sunliquid®

natures´s quality in fuel.



SÜD-CHEMIE
CREATING PERFORMANCE TECHNOLOGY

ABOUT US

Who we are

Süd-Chemie, one of the world‘s leading manufacturers of catalysts and adsorbents, has developed the sunliquid® process for the production of cellulosic ethanol. Süd-Chemie‘s expertise lies in the sector of biocatalyst development and optimization and bioprocess engineering.

Our Business

Süd-Chemie in its central activities in biotechnology and bioprocessing converts lignocellulosic biomass, such as straw, corn stover, bagasse, wood chips and other renewable resources into value added chemical products as for example cellulosic ethanol.

Our Vision

Development of production processes for cellulosic ethanol with better process economics and superior properties compared to fossil-based fuels to solve important issues in the development of alternative energy, climate protection and sustainable mobility.

Cellulosic Ethanol Opportunity

Today´s already widely-marketed first generation ethanol is solely produced from plant matter containing starch or sugar.

Cellulosic ethanol offers a significant improvement in terms of climate and energy balance, based on sustainable, non-food feedstocks. In addition, cellulosic ethanol does not compete with the cultivation of either food or animal feed. According to life cycle analysis, cellulosic ethanol reduces CO_2 emissions by up to 90% compared to conventional gasoline.

BENEFITS

- Generation of value-added products from renewable feedstocks
- Reduced dependency on fossil resources
- Reduction of greenhouse gas emissions
- Sustainable renewable source for fuels and chemicals

Süd-Chemie AG

Süd-Chemie is a specialty chemicals company headquartered in Munich, Germany and operating on a worldwide scale with over 150 years of experience. The common denominator of all Süd-Chemie products and services is the efficient and sparing use of natural resources to enhance the quality of life for humanity and the environment. Key markets served by its Adsorbents Division include the consumer goods, packaging and foundry industries, as well as water treatment. Products manufactured by the Catalysts Division offer solutions for the chemical, petrochemical and refinery industries, for energy storage and hydrogen production, as well as off-gas purification. The industrial biotechnology segment of the company includes the topics biocatalysis and biorefineries. The focus of innovation lays on the efficient use of energy and resources as well as on the generation of bio-based chemicals and fuels. The Süd-Chemie Group generated sales of EUR 1.1 billion in 2009, approx. 80% of these outside Germany. At the end of the year 2009, the group employed more than 6,400 people in its 80 sales and production companies worldwide.

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CREATING PERFORMANCE TECHNOLOGY

Lignocellulose – the Raw Material for Süd-Chemie's sunliquid® Process

Lignocelluloses are the structural cell wall material of biomass from forests and fields. This stable structure is made of cellulose, hemicellulose and lignin, but the quantity varies in different types of plants. Süd-Chemie is able to adapt its sunliquid® process to the different kinds of feedstock in short time.

– Cereal Straw (Wheat, Barley…)
– Corn Stover
– Bagasse (of sugar cane)
– Miscanthus
– Rice Straw
– Wood

Why Lignocellulose?

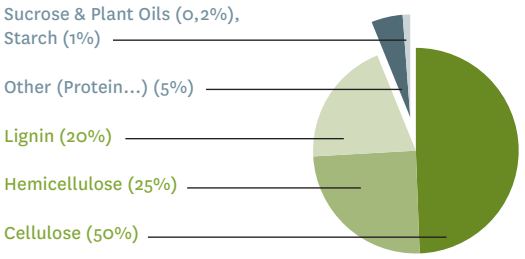

figure 1: Global distribution of different structural biomass (Source: GdCh)

– Cellulose, the main component of lignocelluloses, is the world's most abundant bio-polymer
– Lignocellulose is easily grown with less energy input compared to the same amount of sugar or starch
– The average productivity per ha and year is higher compared to sugar or starch
– Lignocellulose is the main component of agricultural waste, no food-or-fuel discussion

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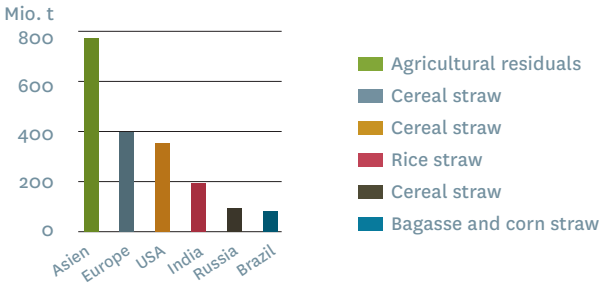
Lignocellulosic Feedstock Availability

The United States, Asia and the European Union (EU) are the leading producers for agricultural by-products such as corn stover and cereal straw. Surplus of corn stover or straw represents an ideal feedstock for cellulosic ethanol production as it does not compete with food or feed applications. In addition to that, biofuel production with this kind of feedstock is not linked to additional land use, as it is a co-product of the current corn and cereal grain production.

main lignocellulosic feedstock in different regions of the world:



In the EU 300 million metric tons of cereal straw are produced per annum as by-products to agriculture. 60% have no alternative usage.

Conversion of this amount of straw would lead to a substitution of more than 20% of the EU gasoline demand with cellulosic ethanol just from straw surplus. This means cellulosic ethanol can play a major role in Europe´s way to sustainable and climate friendly road transport.

By combining advanced conversion technologies, renewable feedstocks, the reallocation of grass- to cropland and the activation of idle agricultural land, it seems to be possible to replace fossil gasoline with cellulosic ethanol in a mid- to long-term perspective.

Source: EUROSTAT

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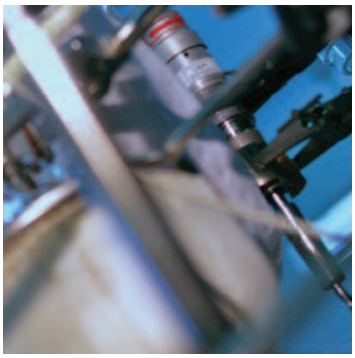
Advantages of Biofuels

Biofuels based on renewable resources offer significant improvements.

– Reduction of greenhouse gas emission
– Reduction of dependency from fossil resources
– Development for rural areas

Advantages of Cellulosic Ethanol

In comparison to corn or wheat based bioethanol, cellulosic ethanol, based on Süd-Chemie's biotechnological process, shows a dramatically improved emission profile contributing to greenhouse gas (GHG) savings and does not compete with cultivation of either food or animal feed.



Potential of Greenhouse Gas Savings

Cellulosic ethanol is a climate friendly fuel. It is made from renewable lignocellulosic residues which also contain lignin – a material that cannot be converted into ethanol but burned to generate energy for the ethanol plant. The overall GHG reduction of the sunliquid® process is up to 90% compared to conventional fuels.

Greenhouse Gas Emissions

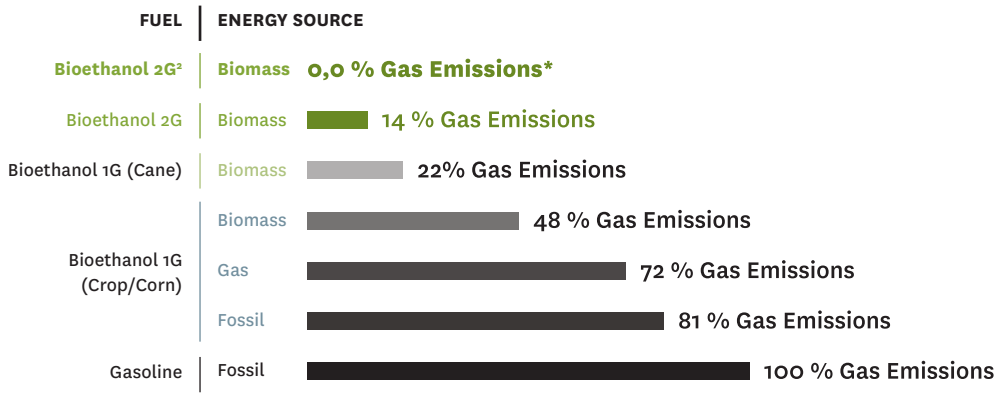


figure 2: Greenhouse gas emissions of different biofuels compared to gasoline
* IEA future estimates, based on a review of recent studies
(Source: acc. to Wang et al, Env. Res. Letters, Vol.2, 024001, May 22, 2007)

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Market Potential for Cellulosic ethanol

Fossil resources are limited but the global demand for fuels is continuously rising and together with national legislations for ambitious targets in biofuel production as well as greenhouse gas reduction, there is an increasing demand for alternative technical solutions to an economically viable supply of bio-based fuels.

Market of Biofuels Today

Bioethanol is the world's main bio-based fuel and the global bioethanol market is still growing rapidly. The global bioethanol production has doubled from 25 billion litres in 2003 to 50 billion litres in 2007.

Source: F. O. Licht

Bioethanol - the world´s main bio-based fuel

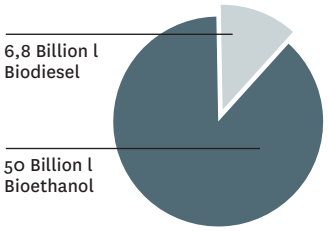


figure 3: Global rate of bioethanol and biodiesel production

Market Drivers for Cellulosic Ethanol: Legislation

The introduction of climate-friendly cellulosic biofuels is supported by the legislative framework prevailing in both the US and the EU.

In the **US**, a law passed at the end of 2007 which stipulates that by 2022, approximately 15 percent of the country ´s annual petrol consumption (currently 137 billion litres) is to be replaced by biofuels, almost 60 percent based on lignocellulosic residues.

The Renewable Energy Directive passed by the **EU** Parliament in April 2009 requires that by 2020, renewable energy must account for at least 10 percent in the transport sector. The annual volumes of surplus cereal straw currently available in the EU would produce more than enough cellulosic biofuels to meet the EC´s 10-percent substitution goal.

sunliquid® PROCESS

SUNLIQUID®- A HIGHLY EFFICIENT PROCESS FOR CELLULOSIC ETHANOL

The sunliquid®-process for cellulosic ethanol matches the ambitious targets for sustainable production and greenhouse gas reduction. We offer turn-key ready cellulosic ethanol plants with independent enzyme supply through a plant integrated, on-site production. In order to provide a high yield, low cost production process for cellulosic ethanol, Süd-Chemie integrated a unique combination of proprietary and state of the art technologies, which distinguishes this process from competitors.

TECHNOLOGY STEPS FOR THE SUNLIQUID®- PROCESS

Pretreatment

Süd-Chemie has developed a pretreatment method which helps to open the stable ligno-cellulosic structure and therefore increase the access to the plant material for enzymes.

Enzyme Production

Süd-Chemie has developed highly optimized enzyme systems for a more efficient hydrolysis of long-chain carbohydrates. This gives the sunliquid®-process high product yields in shorter production times. The enzyme production is carried out on-site at the ethanol plant which reduces the cost significantly and contributes to an economic process.

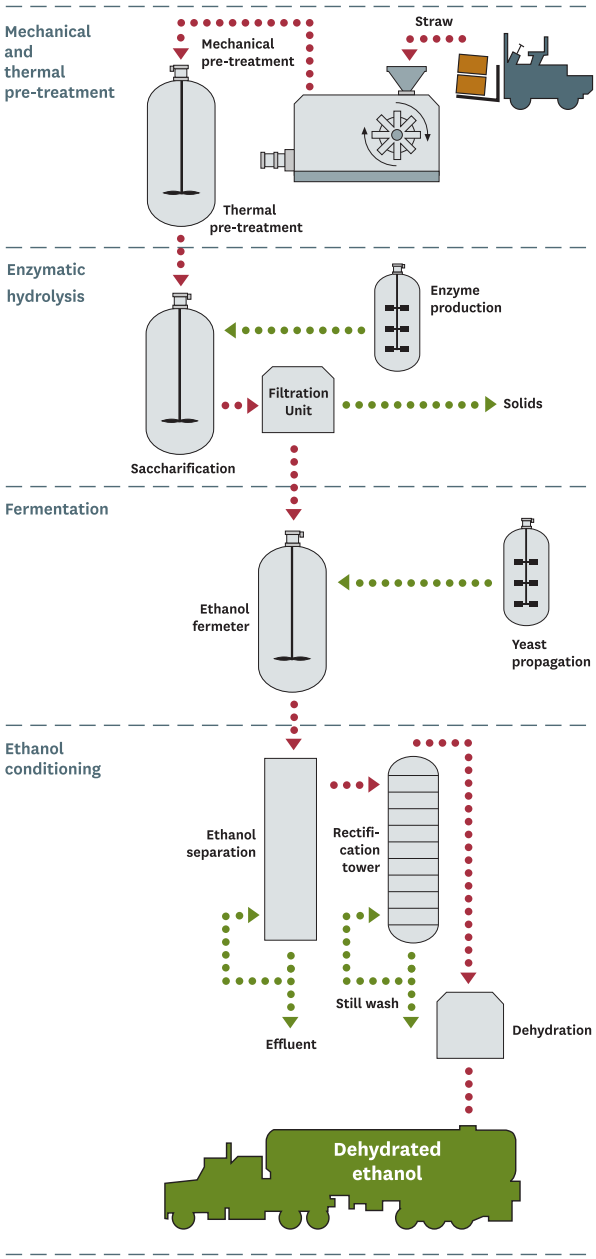
Enzymatic Hydrolysis

With the help of Süd-Chemie's customized enzymes the cellulosic and hemicellulosic fibres will be hydrolyzed into sugar monomers. This stage is also known as saccharification.

Fermentation

Süd-Chemie has optimized yeast strains for an efficient fermentation process resulting in high ethanol yields. This advanced system is using C5 and C6 sugars for ethanol production simultaneously. Combined with a proprietary separation technique this step helps to save up to 50% of energy compared to conventional fermentation and distillation.

Process Overview



sunliquid® PROCESS

SUNLIQUID®-PROCESS

sunliquid®- Key Process Advantages

– Integrated process with state-of-the-art, environment-friendly technology
– Highly efficient process: 5t of cellulosic biomass results in more than 1t of cellulosic ethanol
– Low enzyme costs due to integrated on-site enzyme production
– Fermentation of both C5 and C6 sugars to ethanol simultaneously
– Energy- and water-efficient process
  – Generation of process energy from by-products like lignin and draff
  – Low water consumption due to maximum recycling
– Recovery of minerals as fertilizer

Süd-Chemie Expertise

– Strain development and optimization
– Biocatalyst and bio-processing know how
– Fully automated ultra-high throughput screening method
– Downstream processing know how

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Scale of production plants

PILOT 1 t/a
Process testing and demonstration of technology

First pilot-sized plant with production capacity of about 1 tonne of bioethanol per year commenced operation at the Süd-Chemie R&D site Munich.

DEMONSTRATION 1-2 kt/a
Optimization of energy efficiency and preparation of upscaling

The demonstration plant has a larger technological scale with production of 1,000 to 2,000 tonnes per year.

PRODUCTION 50-150 kt/a
Economically viable plants with high energy efficiency

The production plants will be scaled between 50.000 and 150.000 tonnes a year.

Opportunities for Clients and Investors

- Access to sunliquid®-process for cellulosic ethanol
- Access to Süd-Chemie biocatalysts and bio-processing know how.
- Broad range of possible lignocellulosic feedstocks as enzymes can be optimized to the feedstock which ensures the economically and ecologically efficient operation of a cellulosic ethanol plant.
- Very quick development of effective »enzyme cocktail« for each feedstock, due to Süd-Chemie's automated screening methods.
- Projection of tailor-made state-of-the-art sunliquid® cellulosic ethanol plants for customers on commercial scale: Continuous optimization due to process development, process engineering, process implementation

sunliquid® PROCESS

sunliquid®-Pilot Plant

Süd-Chemie has developed the sunliquid®-process for conversion of lignocellulose to cellulosic ethanol:

The first sunliquid®-pilot plant with a production capacity of about two tons of bioethanol annually was officially opened at the Süd-Chemie R&D site Munich in 2009. It's one-of-a-kind in Germany and represents a scaled-down version of the entire integrated manufacturing process required to convert cereal straw into cellulosic ethanol.

The next step is the construction of the sunliquid®-demonstration plant to show proof of concept, process reliability and economic viability to potential biofuel producers. In interaction with the Süd-Chemie pilot plant, the demonstration plant allows the design and engineering of an industrial-scale production plant for cellulosic ethanol with engineering partners.

Large-scale plants for the commercial production of cellulosic ethanol from cereal straw and other cellulosic residue will follow together with customers. For lower transportation costs the planned production scale plants will be middle-sized in a production range of between 50,000 to 150,000 t/a of cellulosic ethanol.

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Contact
Corporate R&D
Süd-Chemie AG
Staffelseestraße 6
81477 Munich

Germany

Phone: +49 89 710661 0
Fax: +49 89 710661 122

E-mail: sunliquid@sud-chemie.com