WORLD MATERIALS FORUM

6-7 July 2023 - Nancy, France

New Green Engineering Elastomers :

benefits for ressource, enviroment, climate

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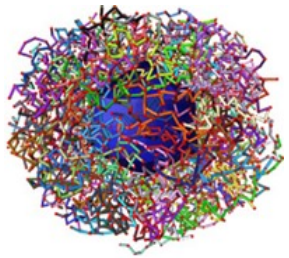
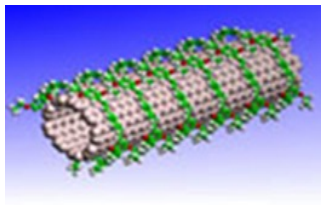
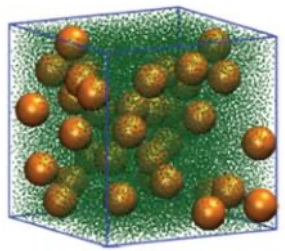
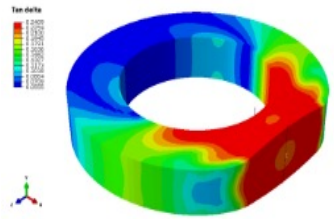
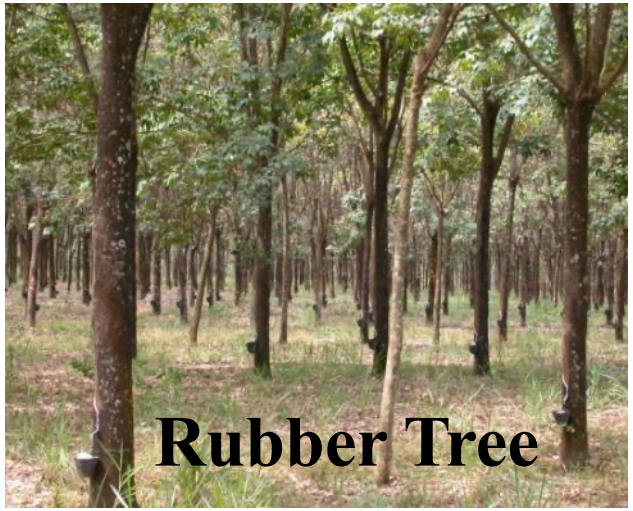






Background

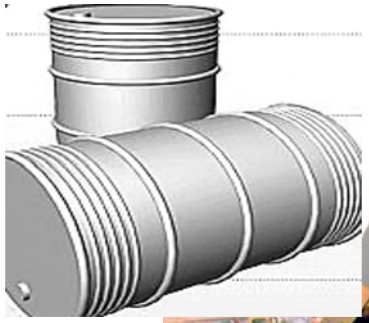
- World rubber consumption in 2021: 29.88 million tons;
- Annual output value of the world rubber industry: > 1 trillion dollars!

Background



Natural Rubber

Output:12.7 million tons (2020)



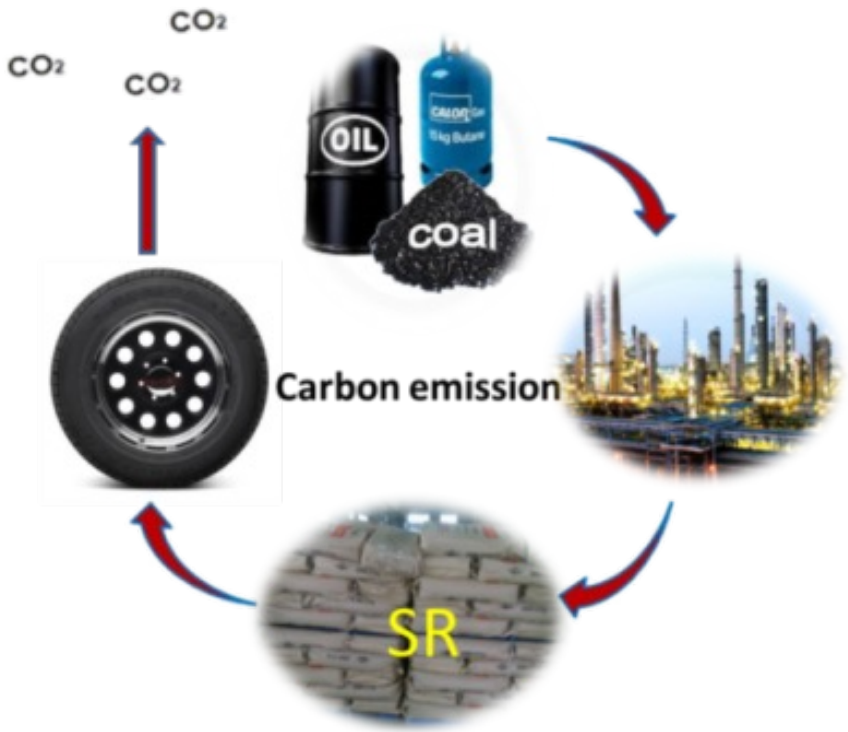
Fossil Energy

Synthetic Rubber

Output:14.4 million tons (2020)

Background

The excess carbon emissions of fossil industry is the main reason leading to climate warming.



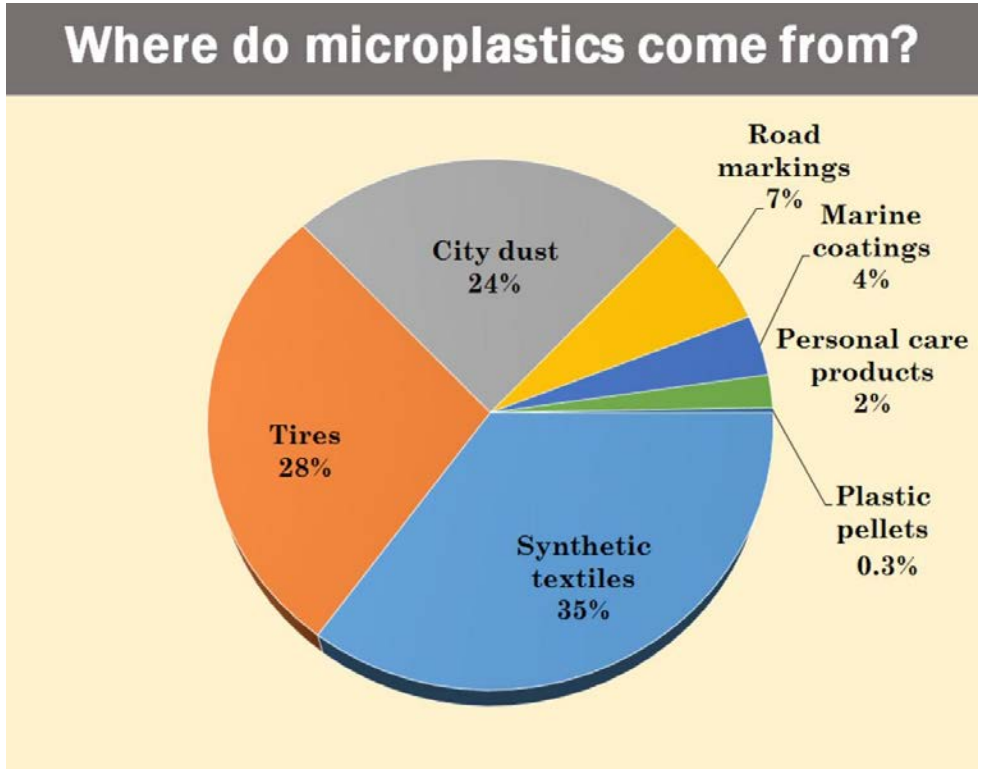
The life cycle of synthetic rubber increases carbon emissions

- Synthetic rubber in 2020: 14.4 million tons.
- CO_2 emission: 2.9 kg CO_2 per 1 kg synthetic rubber.

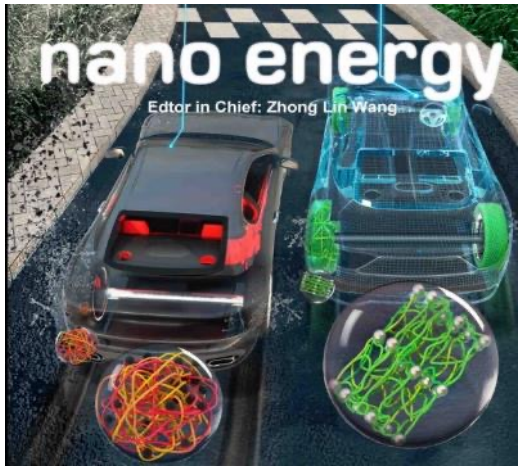
Background

Traditional rubbers are not biodegradable, and the waste rubber products, as well as microplastics from tires, have caused serious pollutions to the environment !

◆**Reported by IUCN (International Union for Conservation of Nature)**



◆**Every year: 1 billion waste tires and 5 billion waste shoes.**



Liqun Zhang*, et.al. Nano Energy, 2018, 48, 180–188

The abrasive dust from tires every year could cover 400 cities like Paris (10cm thick)!

Background

MICHELIN
A BETTER WAY FORWARD

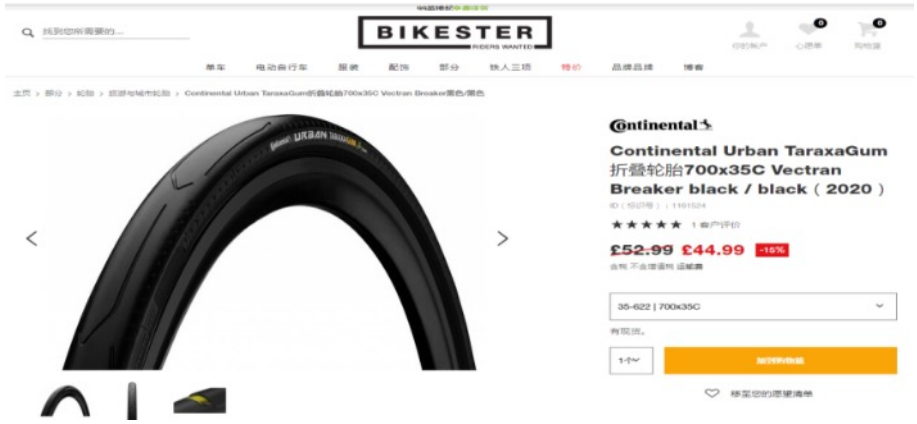
4R CIRCULAR ECONOMY
R REDUCE
R REUSE
R RECYCLE
R RENEWABLE

- By 2030, 20% reduction in rolling resistance of tires;
- By 2030, 50% reduction in CO2 emmisions of tire production;
- By 2030, 40% of raw materials from plants or sustainable sources;
- By 2050, 100% of raw materials from plants or sustainable sources;
- By 2050, carbon neutrality for all factories.

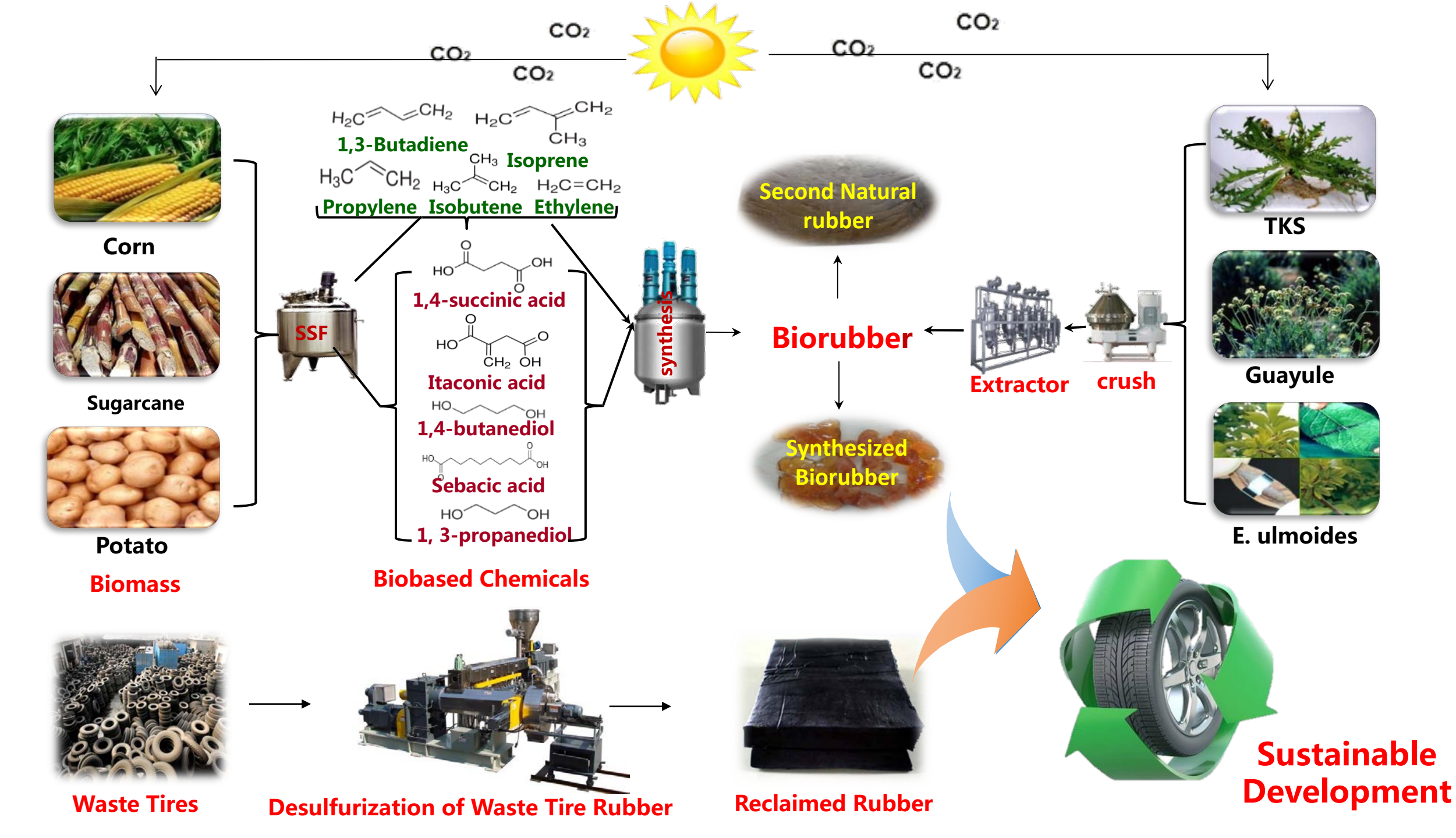
Background

35 million euros invested in developing Taraxacum rubber tires

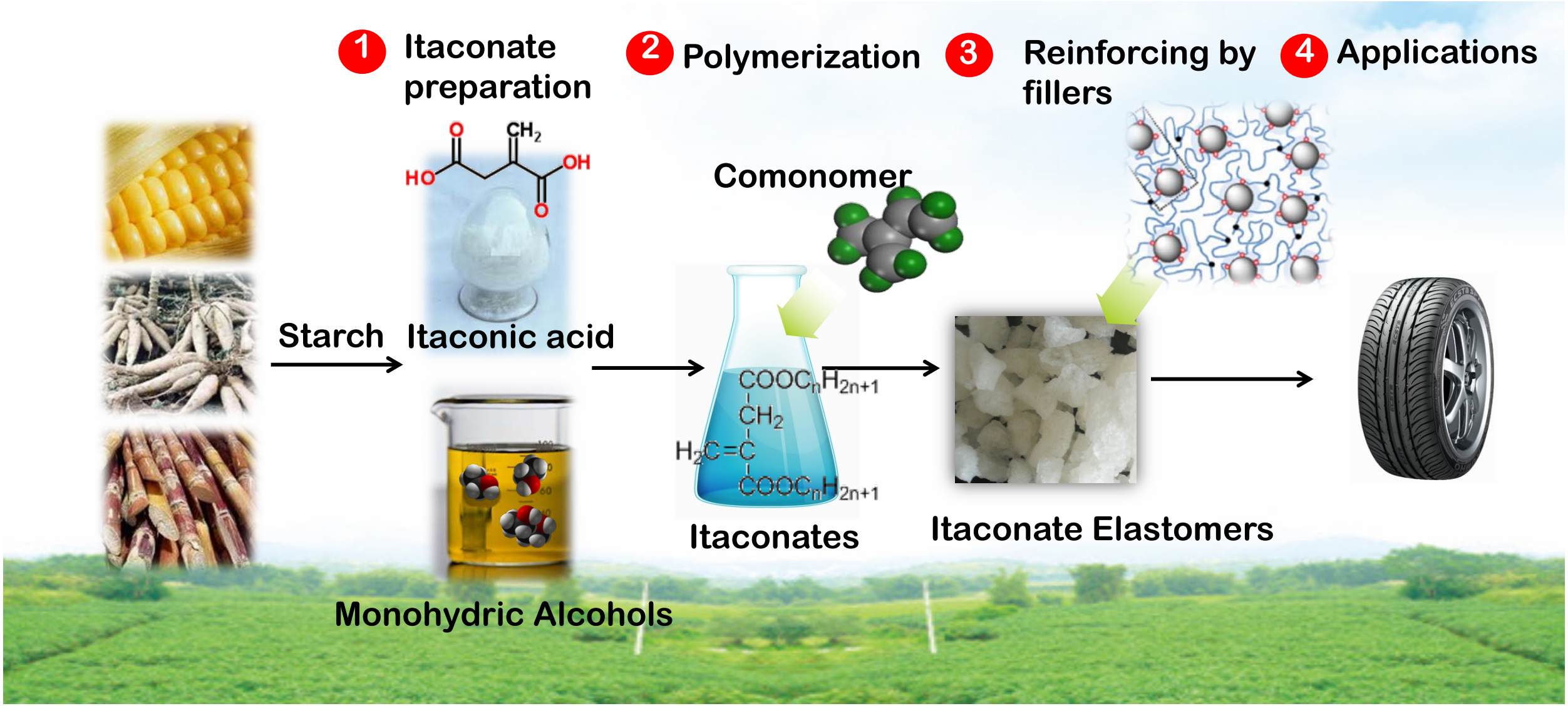
Snow tires made by TKS rubber



Bicycle tires made by TKS rubber


CO2
CO2
CO2
CO2
CO2
CO2
1,3-Butadiene
Isoprene
Propylene
Isobutene
Ethylene
Corn
Sugarcane
Potato
Biomass
SSF
1,4-succinic acid
Itaconic acid
1,4-butanediol
Sebacic acid
1, 3-propanediol
Biobased Chemicals
synthesis
Second Natural rubber
Biorubber
Synthesized Biorubber
Extractor
crush
TKS
Guayule
E. ulmoides
Waste Tires
Desulfurization of Waste Tire Rubber
Reclaimed Rubber
Sustainable Development

Example 1: Biobased Itaconate Elastomer



Industrial production of biobased Itaconate Elastomer

5000t/y Production Line of BIE

Polymerization

Monomer recycling

Latex filling

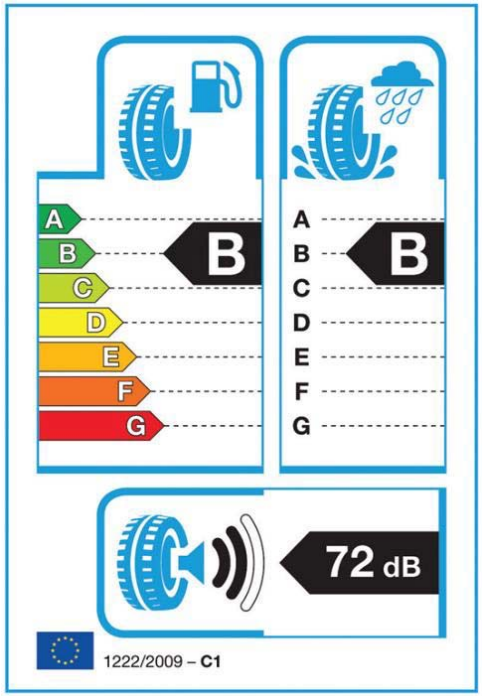
Packaging

Application of Biobased Itaconate Elastomer

◆ The world's first batch of BIE radial tires

BIE tires has been trial-produced and put on vehicles, and its wet skid resistance and fuel saving performance have both reached the Class B in the EU labeling law.

BIE tires on Passenger Cars

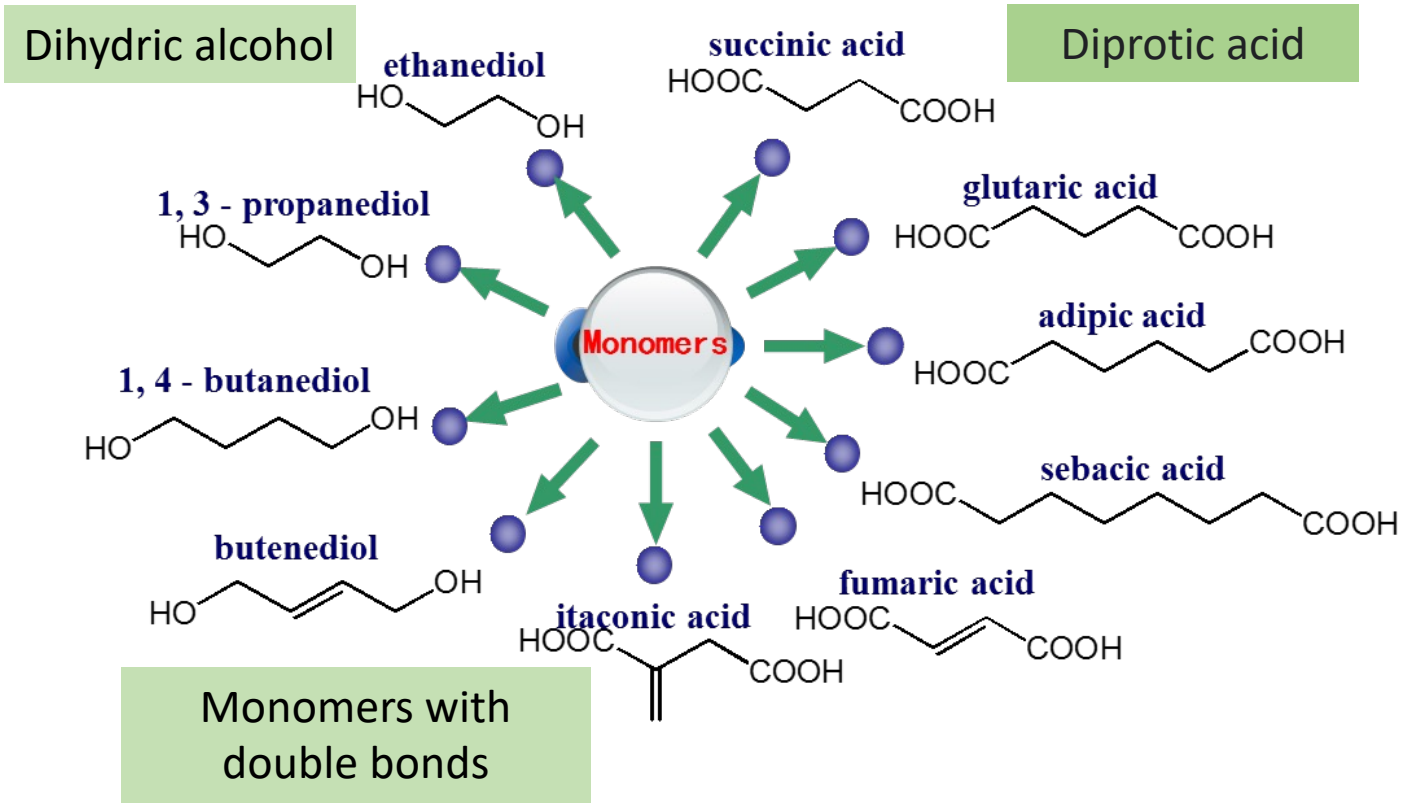


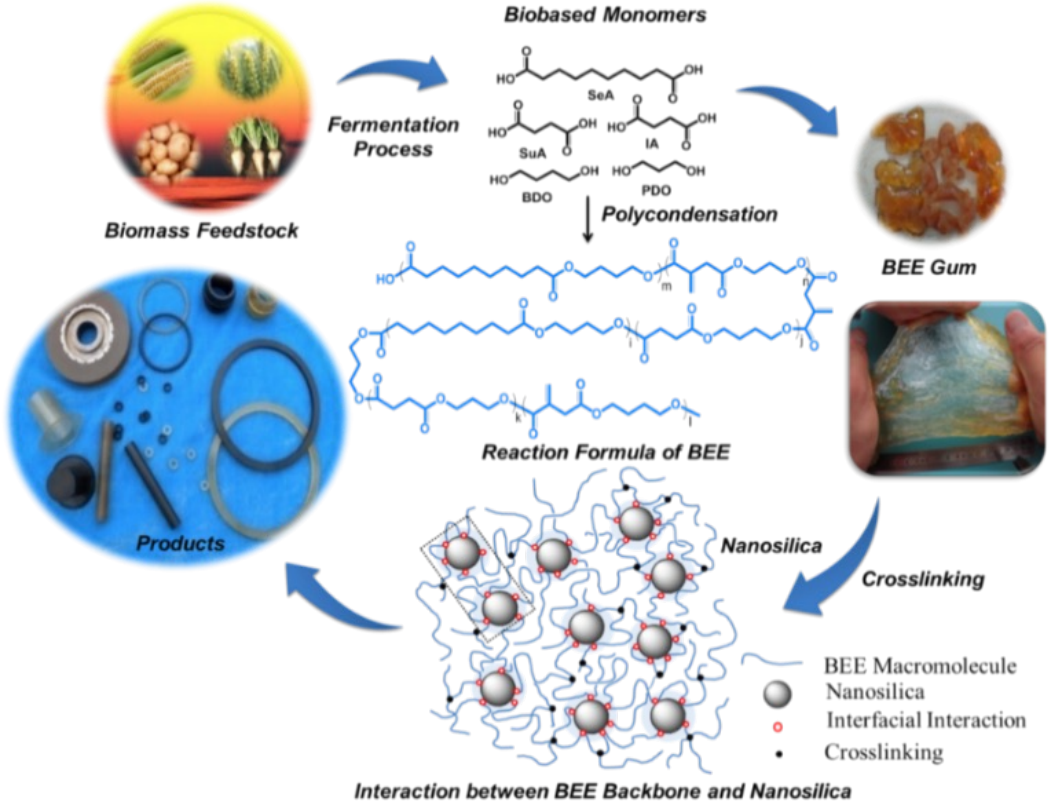
- **Compared with traditional synthetic rubber, in the preparation process, BIE rubber can reduce CO2 emissions by 1.4 tons CO2 per ton of rubber.**
- **10% of the repmacement of synthetic rubberby BIE rubber reduces 2 million tons of CO2.**

Example 2: Biodegradable Polyester Rubber

How to develop a new biobased and biodegradable rubber?

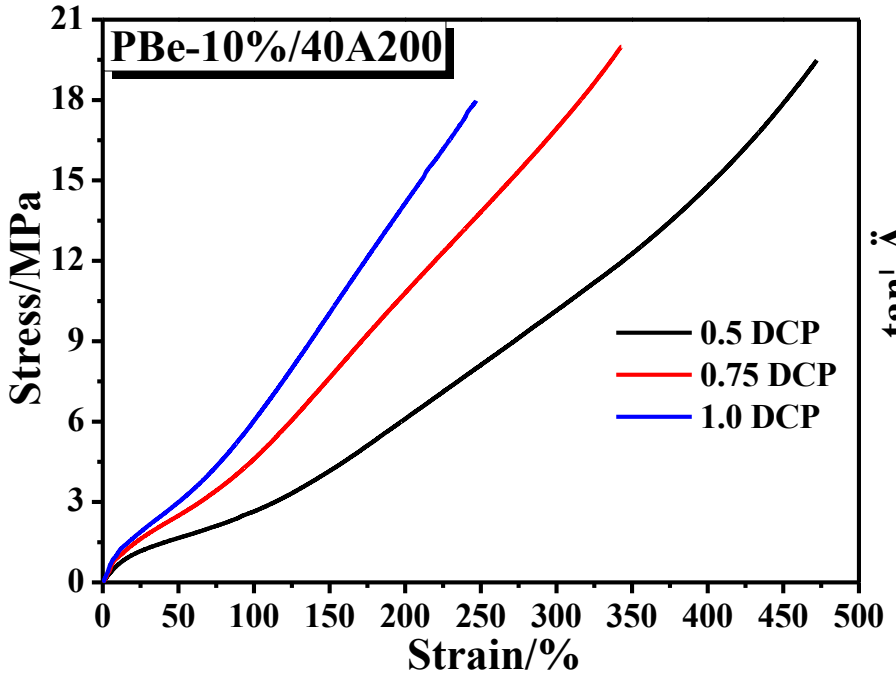
- ☐ Introduce ester groups into the main molecular chain of rubber
- ☐ Break the crystallization of the polyester rubber
- ☐ Introduce unsaturated monomer to provide double bonds

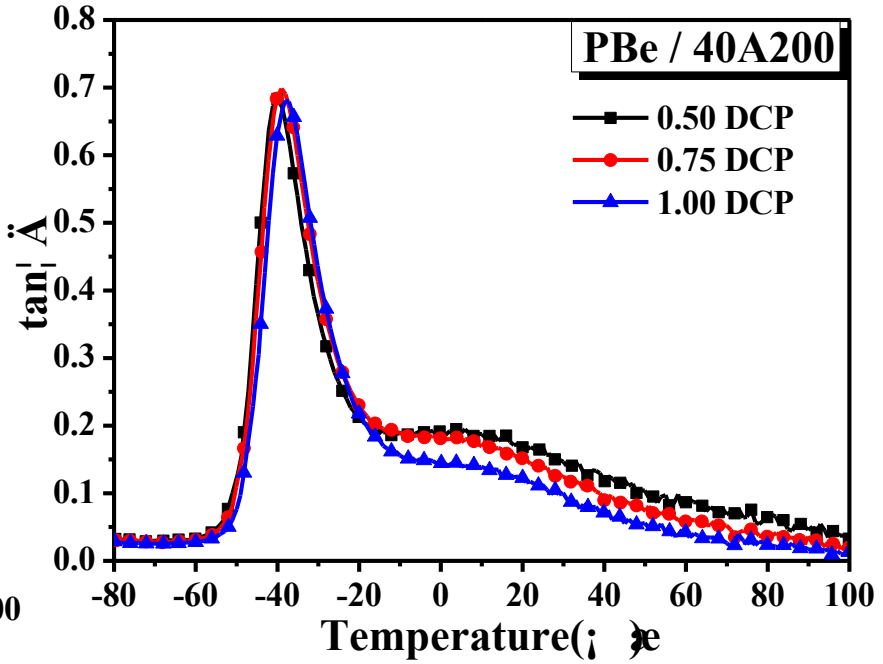




Mechanical performances of Biodegradable Polyester Rubber

Biodegradable tire



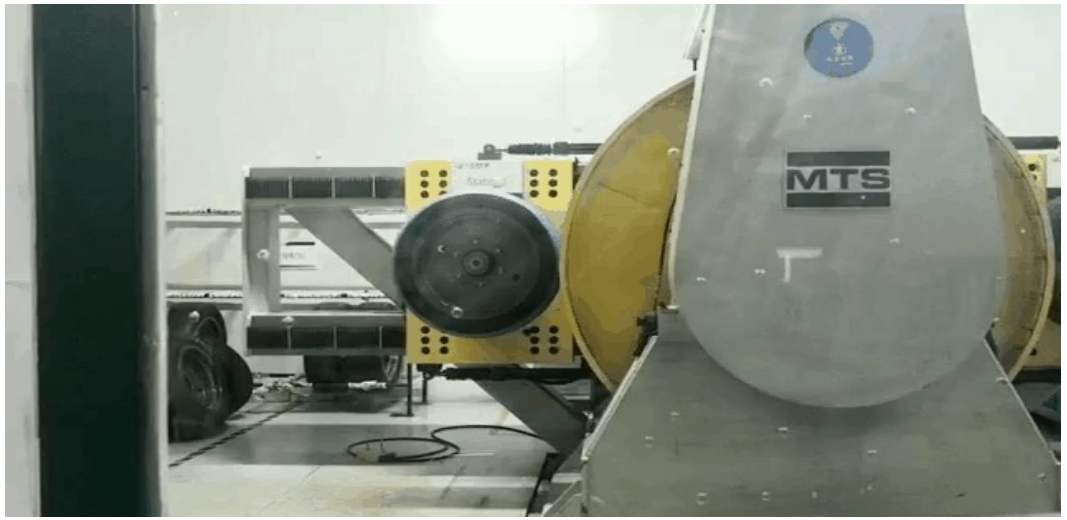


	Tensile strength (MPa)	Modulus at 100% elongation (MPa)	Modulus at 300% elongation (MPa)	Elongation at break(%)	Shore A hardness	Tanδ @ 60°C @ DMTA
Biodegradable tire tread	**20.0**	**4.6**	**16.9**	**343**	**71**	0.058
Commercial green tire tread	**18.0**	**2.5**	**12.0**	**450**	**75**	0.082

Application of Biodegradable Polyester Rubber

The world first biodegradable tire, aiming to solve the microplastics problem (6 million tons per year) produced by tires

We developed a key key technology for biodegradable tire processing, and prepared the first biodegradable tire in Shandong Linglong tire Co.



- Tire rolling resistance up to "B" grade
- Passed the tire speed and durability test

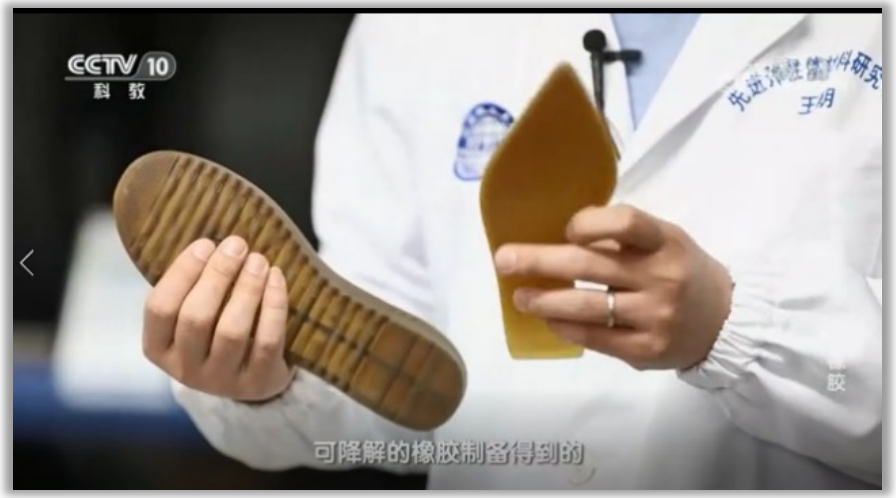
Application of Biodegradable Polyester Rubber

The world first fully biobased and biodegradable shoes

Three technical issues solved:

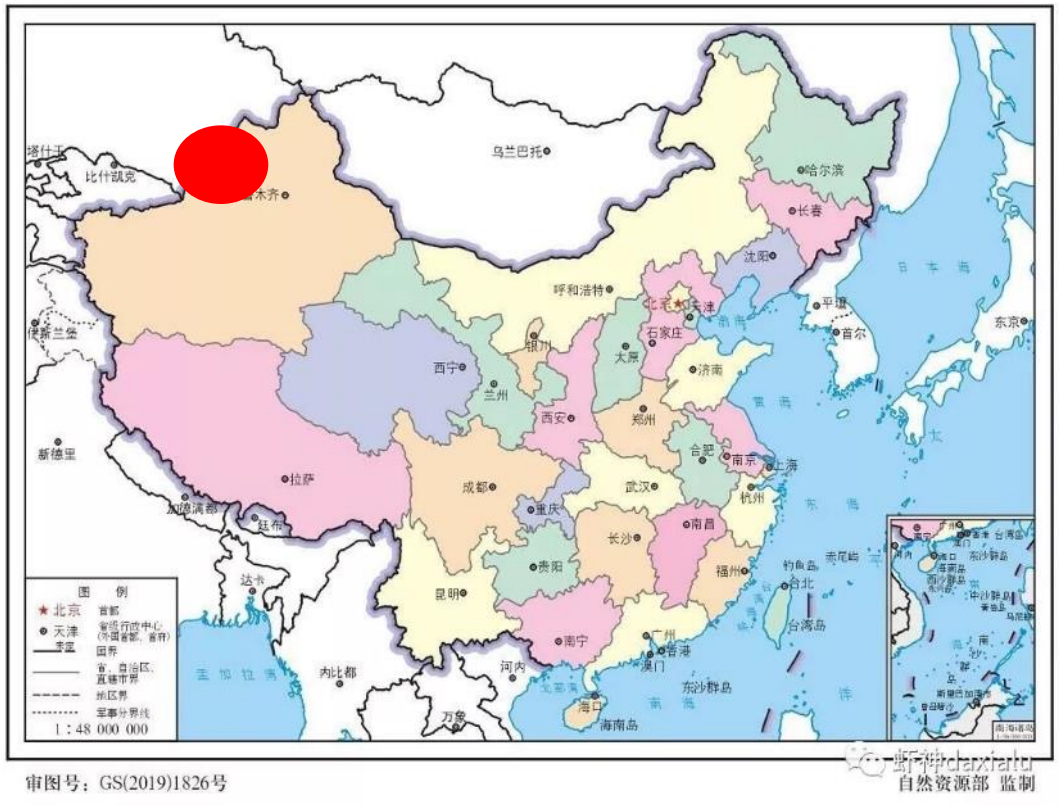
- Optmized the trade-off between hardness, abrasion and flexural properties,
- Improved the processability,
- improved the adhesive strength of shoe sole and upper.

- Insole： Corn stalk latex
- Upper : Hemp fiber
- Sole : BBPR



Preparation and development of TKS rubber

Taraxacum kok saghyz (TKS) rubber is native to the border of Tianshan Mountains between China and Kazakhstan



TKS rubber produces the rubber in the form of latex as well, the chemical structure is the same as natural rubber.

Preparation and development of TKS rubber

TKS Rubber Technology Development and Innovation Alliance

Launched the Triangle Alliance in 2012

In 2013, Heilongjiang Academy of Sciences Joined

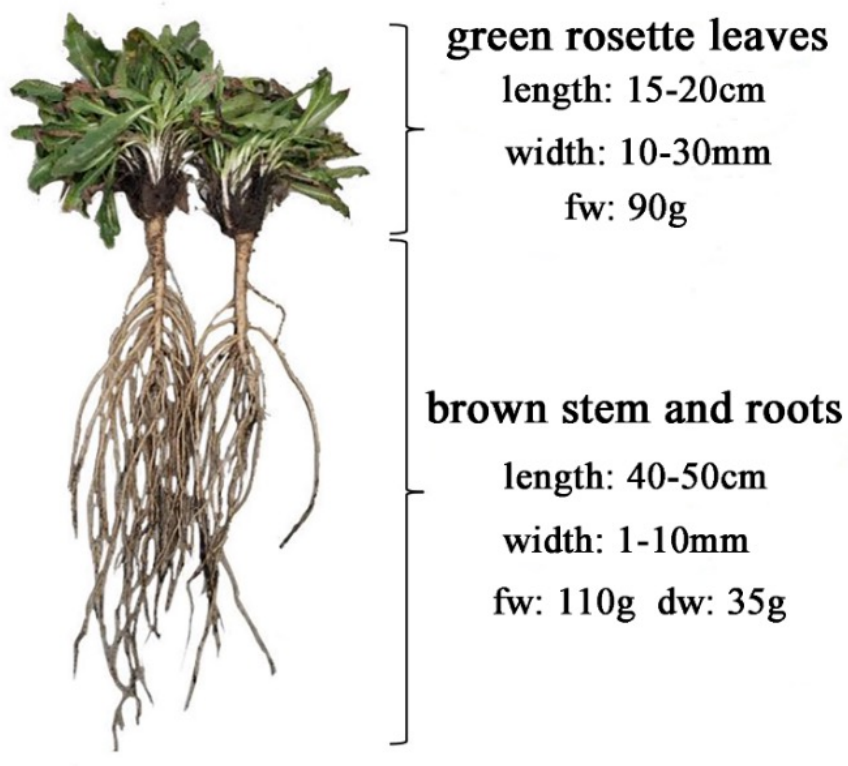
In 2015, 19 institutes were gathered to formally establish the TKS rubber Alliance, forming full industry chain development.

Forming full industry chain from efficient breeding to tire development

Germplasm, breeding, cultivation, extraction, products, comprehensive development

Preparation and development of TKS rubber

Analysis of external morphology and internal structure of rubber root



Three parts TKS root: root bark, root flesh and root core. About 54cm long, diameter 0.8 ~ 5cm, weight 50-100g, water accounted for 70%.

Preparation and development of TKS rubber

Pilot production line of TKS rubber (100t/y)

Planting area> 70ha

Rubber content>5%

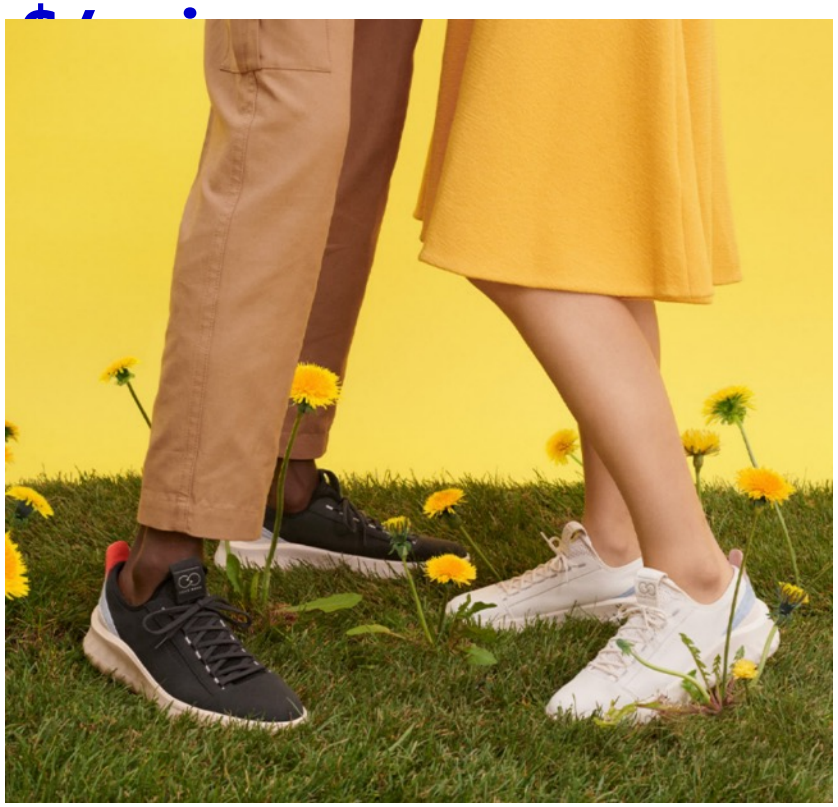
TKS concept rubber

ZL 2019224272133，CN211865298U，CN209284254U、CN207384892U

The properties of the prepared TKS rubber reached the level of RSS, and the TKS rubber concept tire was produced.

Preparation and development of TKS rubber

TKS rubber was used to make the high-end shoes material in 2022. The Cole Haan brand sold 1 million pairs in 2022 with a price of 130



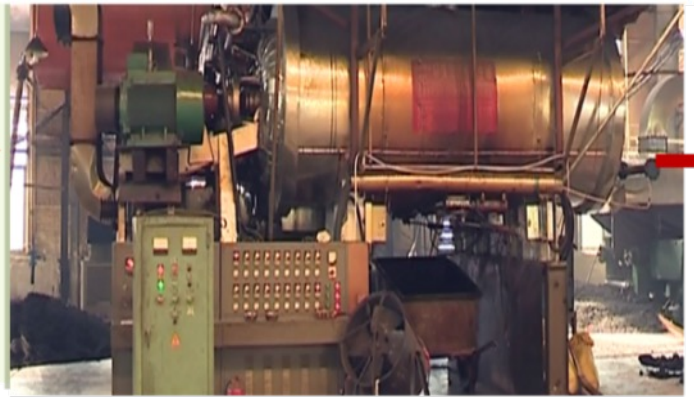
Sale plan in 2023: 12 million pairs of TKS rubber foam shoes

Desulfurization of Waste Tire Rubber by Multi-stage Screw Extruders

Traditional Method

Rubber Powder & Softeners & Additives

High Temp and Pressure Risk; High Air and Water Pollution



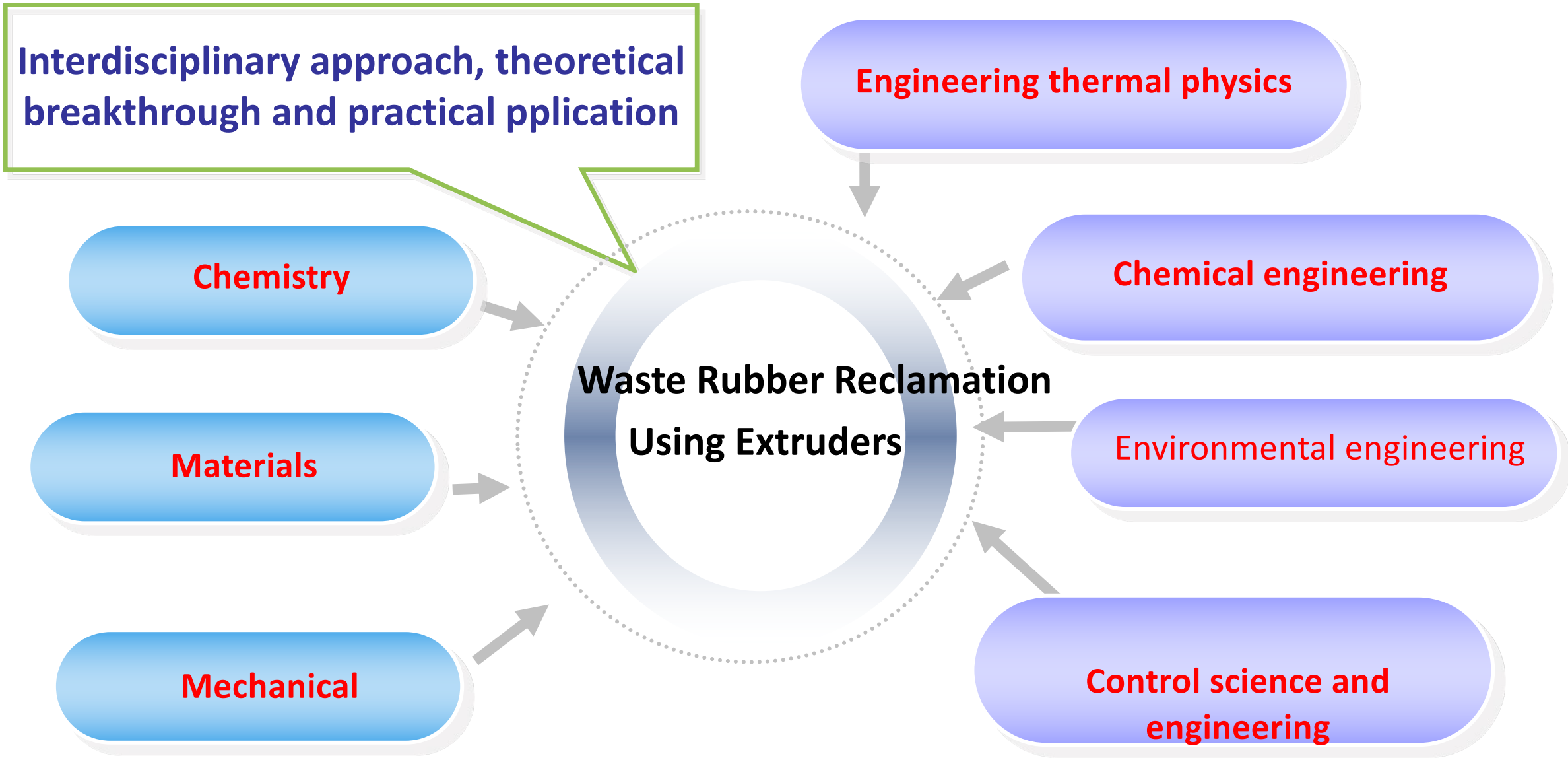
High Air Pollution; Safety Risk

Reclaimed Rubber

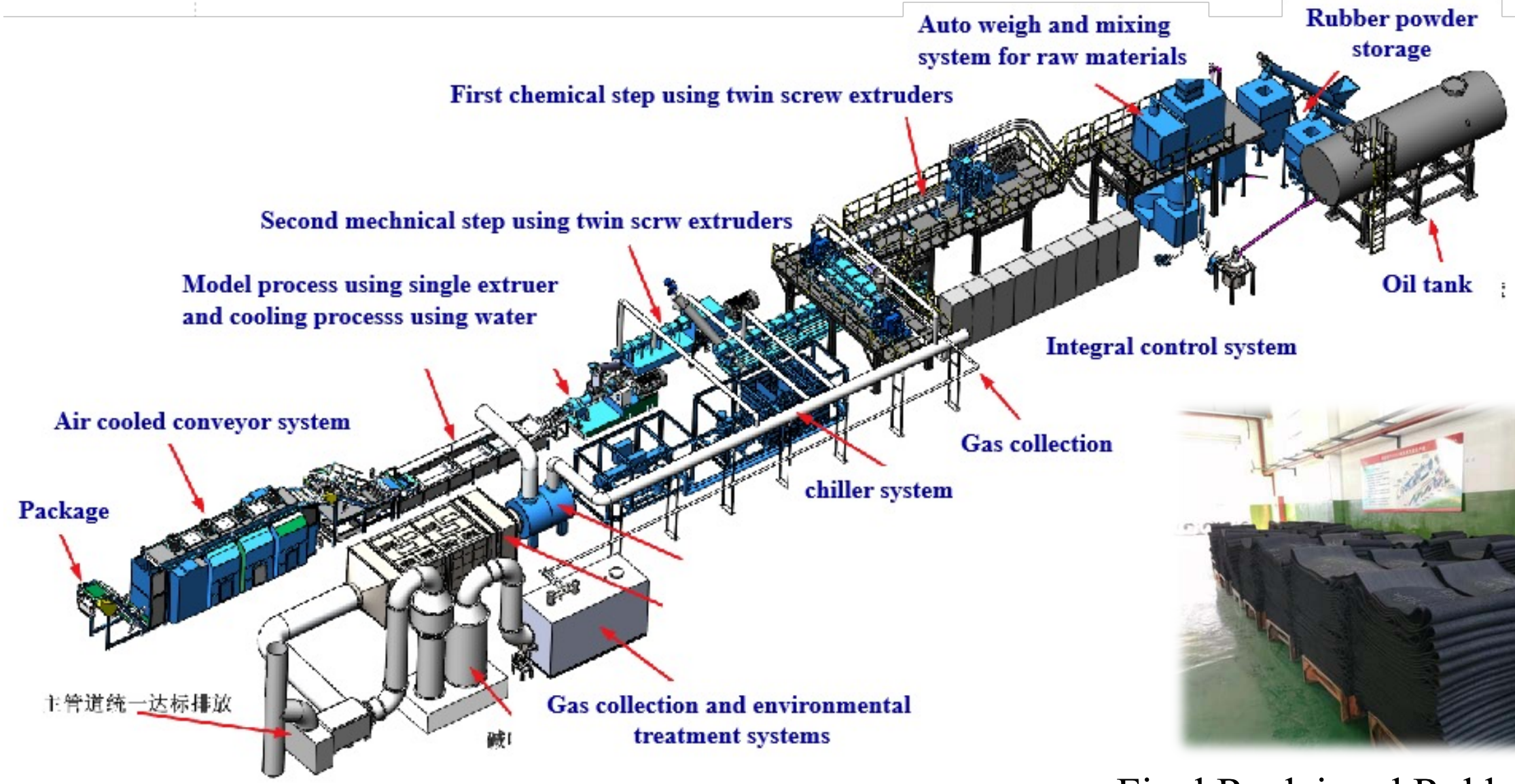
First Chemical Desulfurizing Step - - - - - - → Second Mechanical Shearing Step

Our goal: to develop a continuous, green, safe, high and consistent quality desulfurizing process.

Desulfurization of Waste Tire Rubber by Multi-stage Screw Extruders



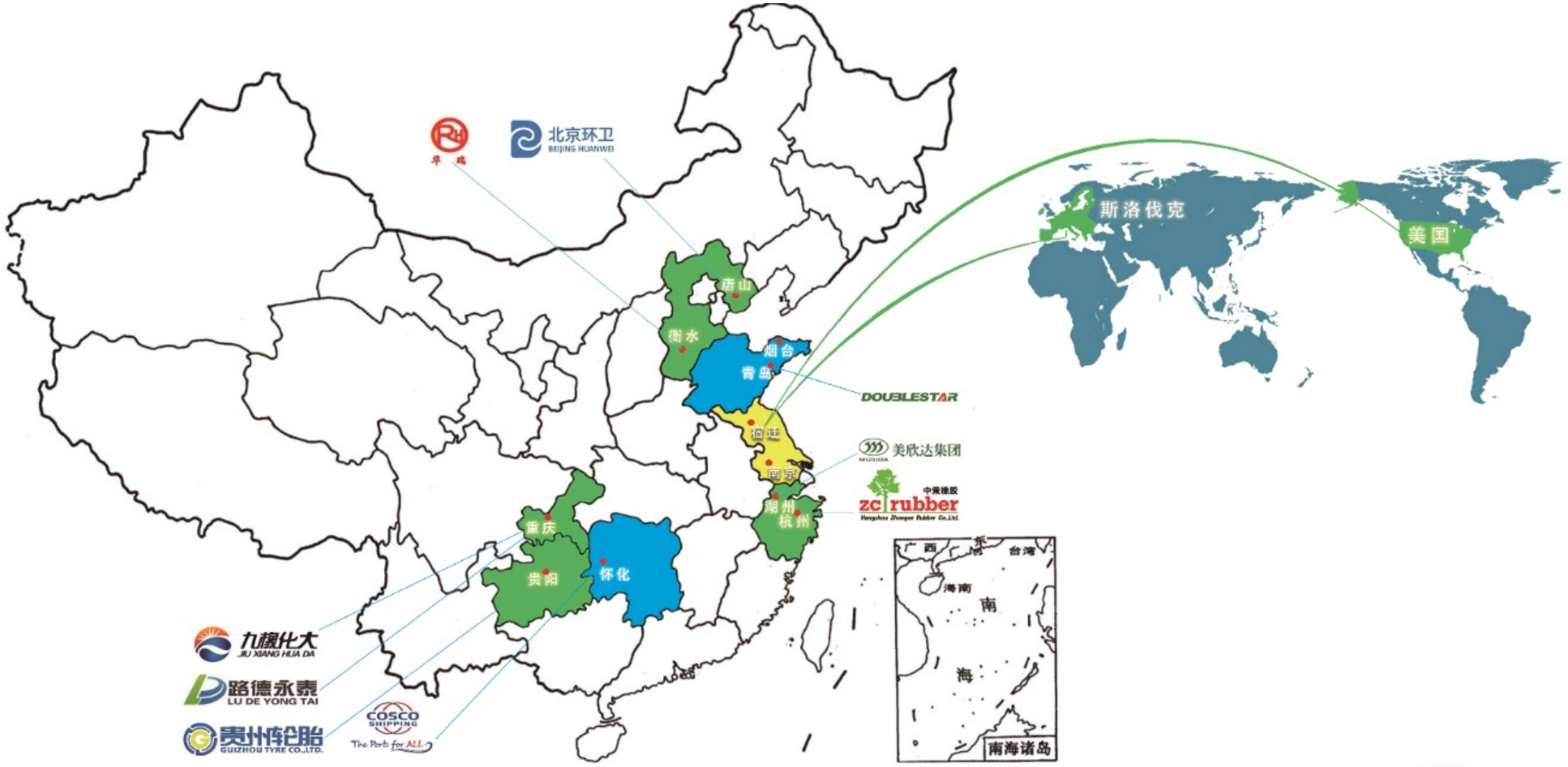
Desulfurization of Waste Tire Rubber by Multi-stage Screw Extruders



Final Reclaimed Rubber Product

Desulfurization of Waste Tire Rubber by Multi-stage Screw Extruders

More than 10 product lines have been running, bringing remarkable social, economic en environmental benefits.



Desulfurization of Waste Tire Rubber by Multi-stage Screw Extruders

- Multi-stage screw production line for reclamining used rubbers
- Annual output: > 80,000 tons (1.3 million used tires)

Scale up plan from 2023

Items	2023	2025-2026	Benefits
Biobased Itaconate Elastomer	5000 t/year	50000 t/year	70 kt CO_2 reduction
Biodegradable Polyester Elastomer	1000 t/year	30000 t/year	52 kt CO_2 reduction
TKS rubber	100 t/year	2000 t/year	6 kt CO_2 reduction
Reclaimed Rubber	80 kt/year	200 kt/year	Recycling of 3.4 million tires

ACKNOWLEDGEMENT

- NSFC, MOST, MOE,SINOPEC
- Ling Long Tire Co., Goodyear Tire and Rubber Co., Red Avenue Co., Pirelli Tire Co. , Shand Dong Chamboard Co.
- A team of 6 professors and over 100 graduate students.