



体育运动材料的研究进展及成果应用

Research Progress and Application of Sports Materials

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华东理工大学
East China Univ. of Sci. & Tech.





提纲 Outline

- 机构简介 Organization Introduction
- 研究方向 Research Area
- 研究进展 Research Progress





机构简介 Organization Introduction

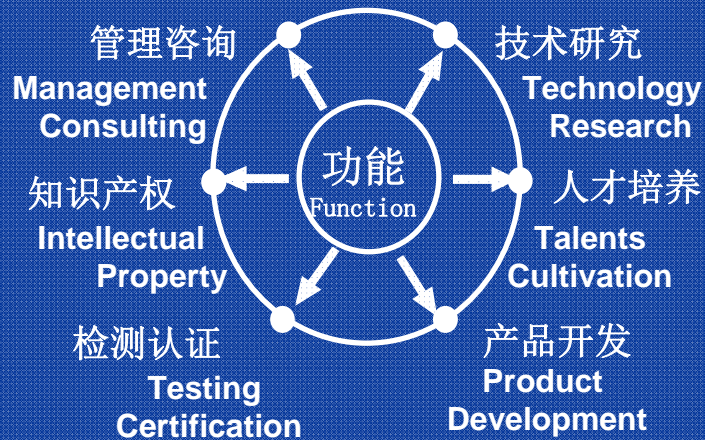


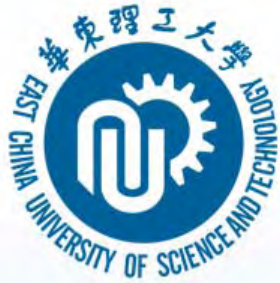
依托华东理工大学学科优势和研究基础；
Relying on the discipline advantages and research basis of ECUST

以“自主创新推动行业技术进步，为中国体育运动材料产业的发展服务”为宗旨；
Aiming at “Independent innovation promoting technological progress, serving for the development of Chinese Sports Materials Industry”

研究运动材料行为学，设计与开发体育运动材料；
Investigate sports materials behavior, design and develop sports materials

全职研究开发人员**15**名，教授**3**名，副教授**6**名。
15 full-time R&D staff, 3 professors, 6 associate professors





发展历程 Development History

上海市体育运动材料技术服务平台

Shanghai Sports Materials R&D Service Platform

体育运动材料博士点

PhD program in sports materials

体育、材料、机械学科交叉

Interdisciplinary research of Sports, Materials and Machinery

华理泰山体育新材料研发中心

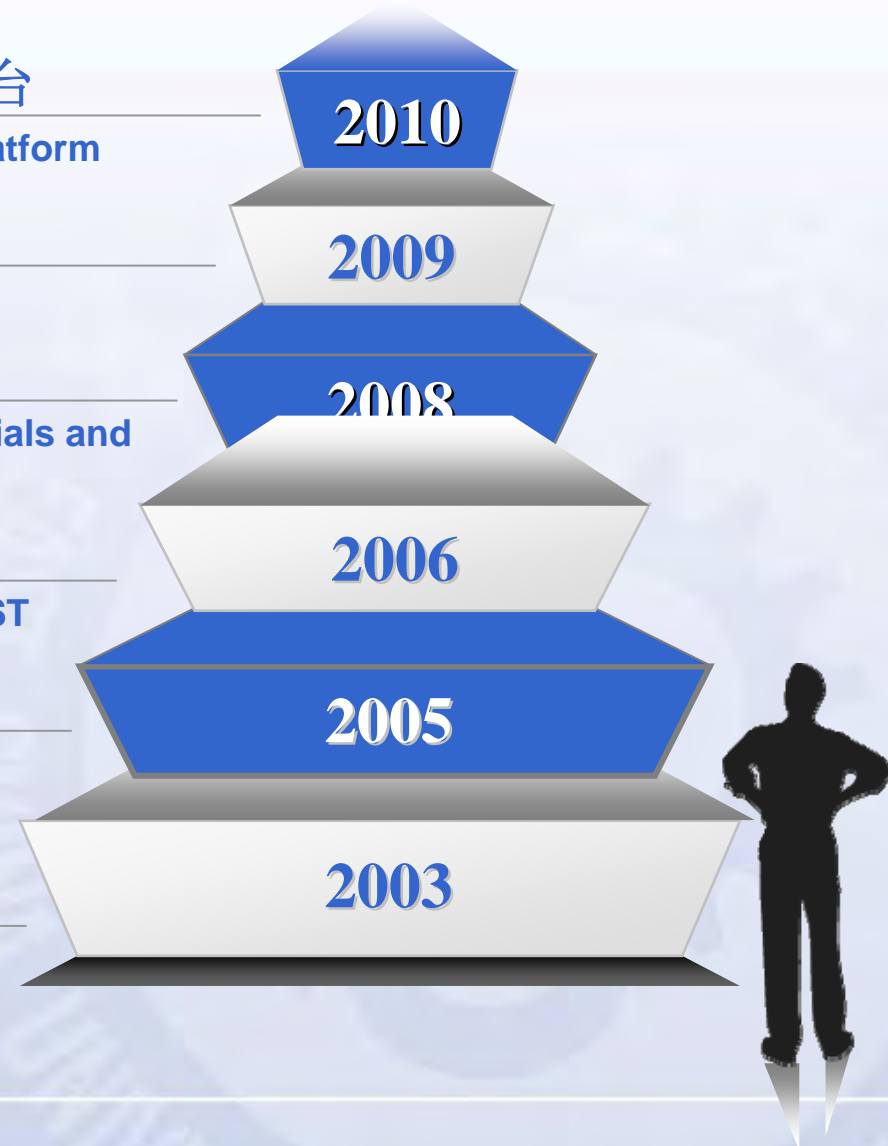
R&D Center for New Sport Materials, ECUST

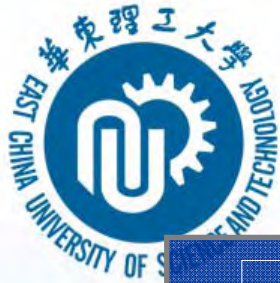
华理体育新材料应用推广中心

Application Promotion Center for New Sports Materials, ECUST

产学研合作实验室

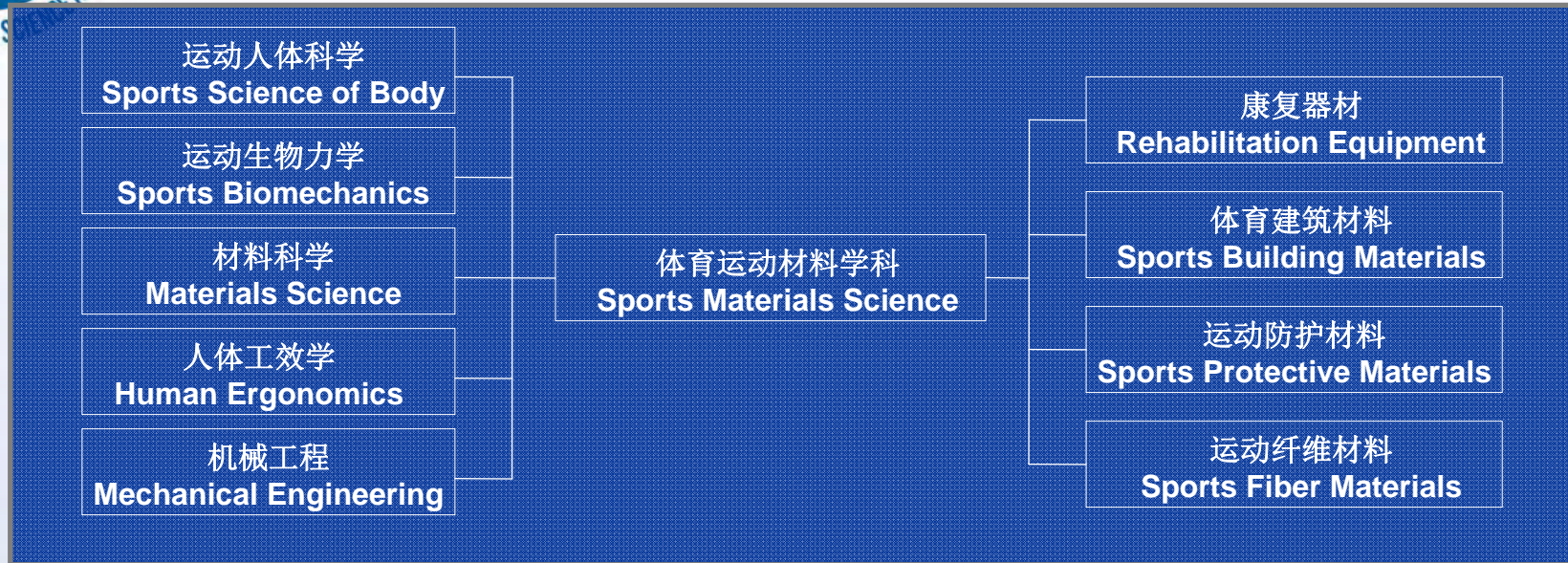
Establishment of cooperative laboratory



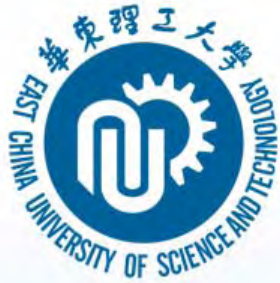


体育运动材料学科

Sports Materials Science



- 体育学(运动人体科学)和工学(材料科学、机械、工程等)相交叉的新型学科;
New interdisciplinary of Sports Science (Sports Science of Body) and Engineering (Materials Science, Mechanics, Engineering, etc.)
- 研究运动主体—运动客体—环境之间的相互作用关系, 建立人体运动安全行为和康复训练新的研究方法以及体育器材新的设计方法;
Investigate the relationship of sports subject, object and environment, and establish new studying method for safe behavior of body, rehabilitation and designing sports equipment
- 研究人体、器材、场地三元体系中人体运动机能变化规律, 材料与器械服役中结构变化规律, 形成体育材料与器材开发的基础理论与核心技术
Study the variation in human motion function in the ternary system of human body, equipment and field and structure of materials and equipments in serve to form the basic theory and key technology for sports materials and equipment development



研究进展 Research Progress

标题

功能型网球拍弦关键技术研究

Key technology research
on functional tennis
racket strings

体能康复功能型力量训练
关键材料的研究

Key technology research
on functional strength
training of physical
rehabilitation

地源热泵地下灌浆材料研究

Research on grouting materials
for ground source heat pump

功能性运动安全涂层材料关键
技术研究

Key technology research on anti-
skid coating of sports ground

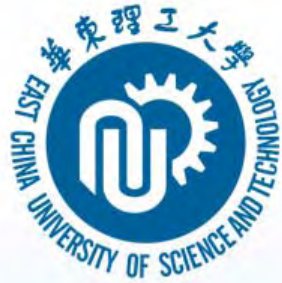
运动场地用人造草坪关键技
术研究

Key technology research on
artificial turf

运动安全防护发泡材料关键
技术研究

Key technology research on
movement security foaming
material

Achievements



研究进展 Research Progress



Enhancement of wear resistance, strength, anti-shrinkage, etc.

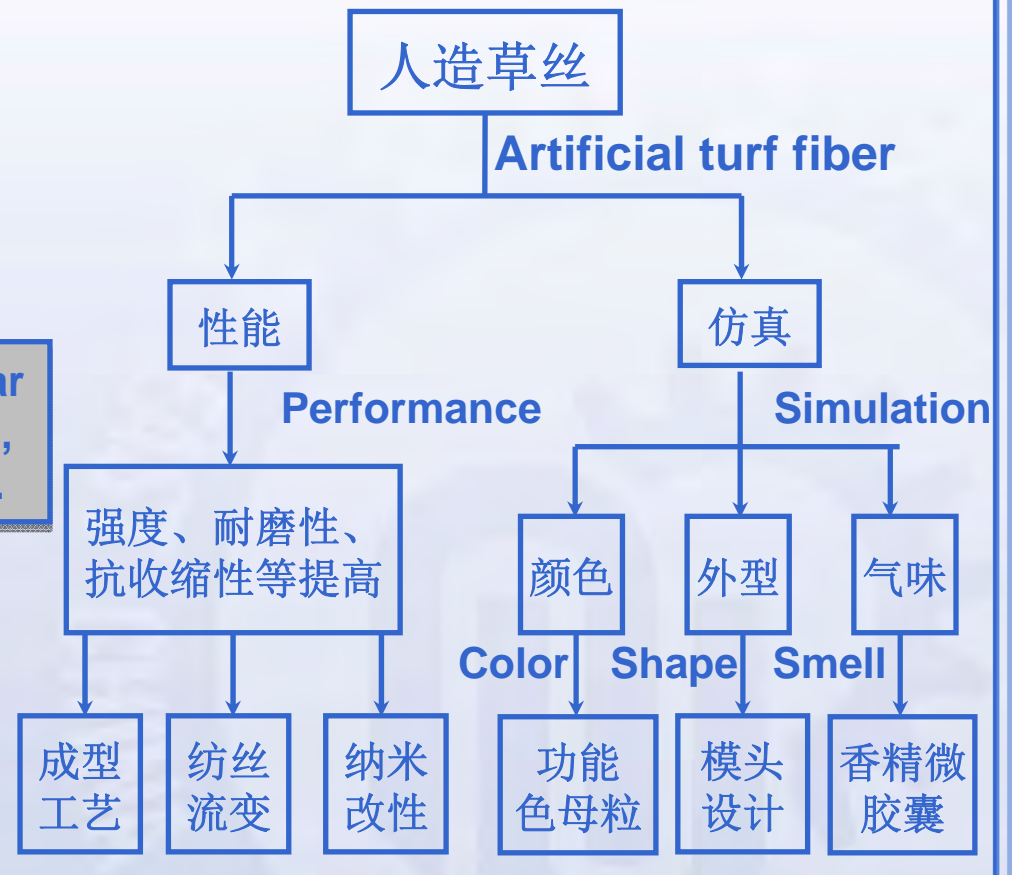


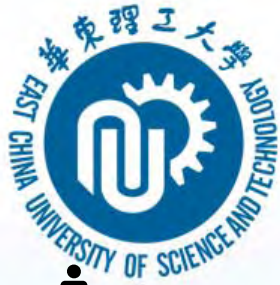
济南一中国际足联FIFA认证场地

Functional color materbatch

Die design

Fragrance microcapsule





人造草丝

Artificial turf fiber

性能

Performance

成型工艺

Shaping process

纺丝流变

Spinning rheology

纳米改性

Nano modification

研究进展 Research Progress

运动场人造草丝纤维制备采用熔融纺丝法:

熔融挤出、拉伸、热定型

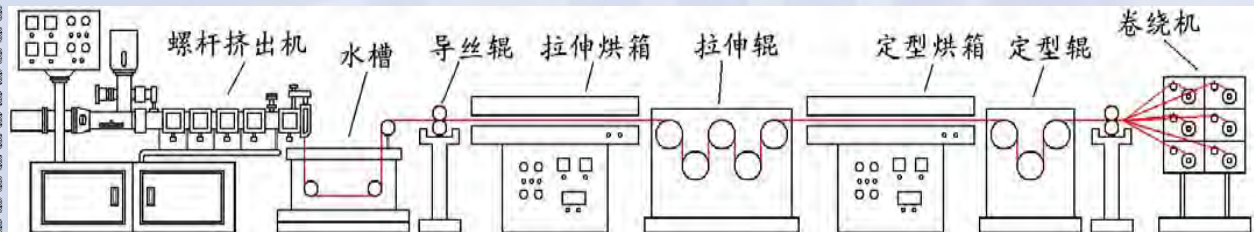
Melting spinning-melt extrusion, tensile,

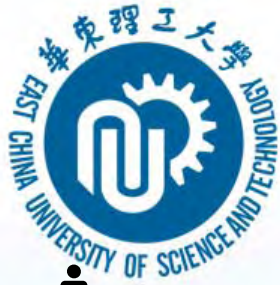
拉伸比 draw ratio	3	4	5	6
$T_s/^\circ\text{C}$	91.67	91.29	90.98	91.46
$T_p/^\circ\text{C}$	124.13	123.92	123.45	123.76
$T_f/^\circ\text{C}$	127.48	127.45	127.47	127.45
$\Delta T/^\circ\text{C}$	35.81	36.16	36.49	35.99
$X_c/\%$	30.98	31.87	32.32	32.90

增大拉伸比对于草丝纤维熔融过程的特征温度影响很小
The draw ratio has little effect on the characteristic temperature of melting process of fiber

拉伸比增大, 结晶度略有提高
The crystallinity increases with the draw ratio increasing

注: T_s , T_p , T_f 和 ΔT 分别为熔融峰的起始温度 T_{start} , 峰值温度 T_{peak} , 终止温度 T_{finish} 和峰宽peak width, X_c 为结晶度 crystallinity.





人造草丝

Artificial turf fiber

性能

Performance

成型工艺

Shaping process

纺丝流变

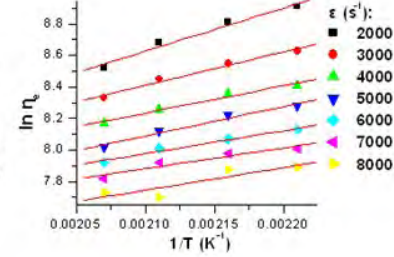
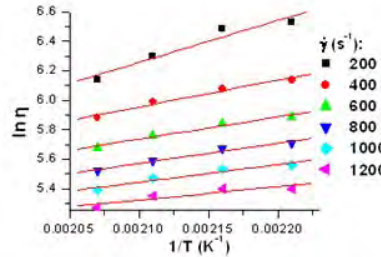
Spinning rheology

纳米改性

Nano modification

研究进展 Research Progress

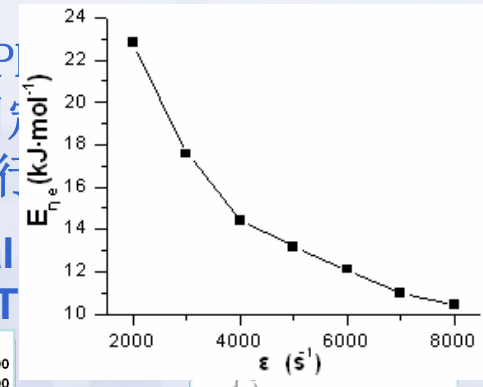
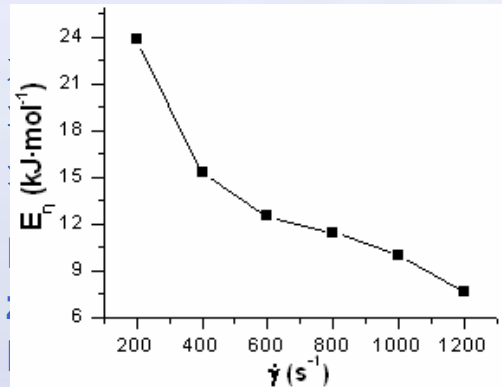
- 纺
- 人造草丝挤出行为
- 流变学



的流动
flow in

人造草丝挤出行为属于单轴流变学

Viscous flow activation energy of die



剪切流动
Shear flow

拉伸流动
Elongational flow

速率越大，粘流活化能越高，粘度对温度越敏感

The viscous flow activation energy increase and the viscosity gets more sensitive to temperature with shear rate increasing.



研究进展 Research Progress



人造草丝

Artificial turf fiber

性能

Performance

成型加工

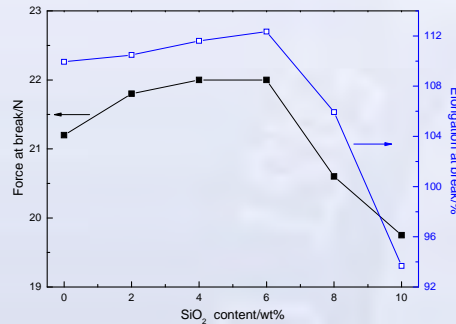
Shaping process

纺丝流变

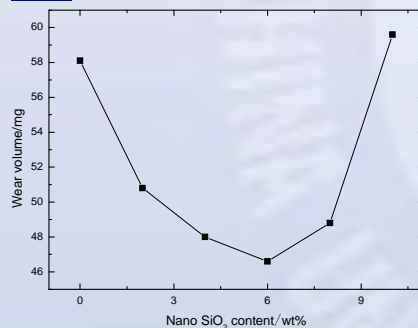
Spinning rheology

纳米改性

Nano modification



纳米SiO₂含量对草坪纤维力学性能的影响
Influence of nano-SiO₂ content on mechanical properties of turf fiber



纳米SiO₂含量对草坪纤维抗磨损性能的影响
Effect of nano-SiO₂ content on wear resistance of turf fiber



研究进展 Research Progress



人造草丝

Artificial turf fiber

仿真

Simulation

颜色仿真

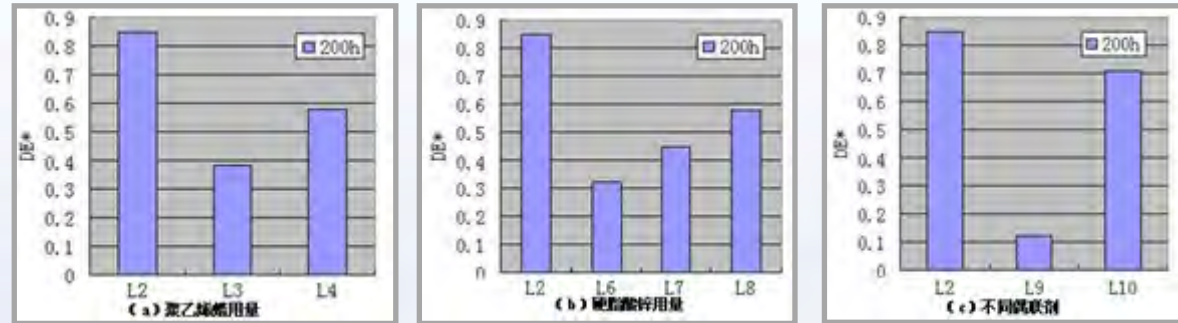
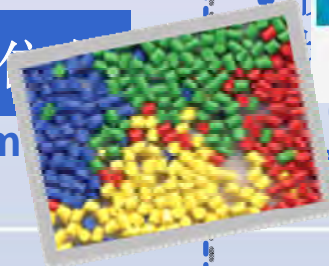
Color simulation

形状仿真

Shape simulation

气味仿真

Smell simulation



- 添加适量聚乙烯蜡，可改善颜料分散性，提高着色力

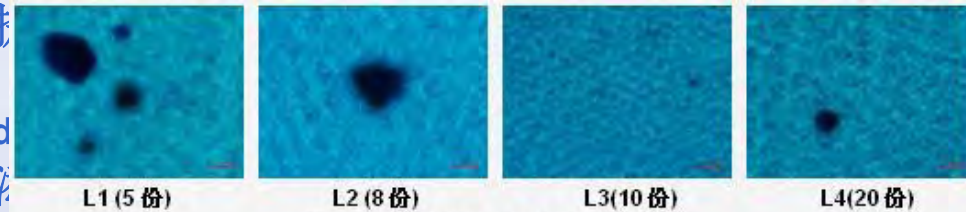


图1 不同聚乙烯蜡用量的颜料分散照片

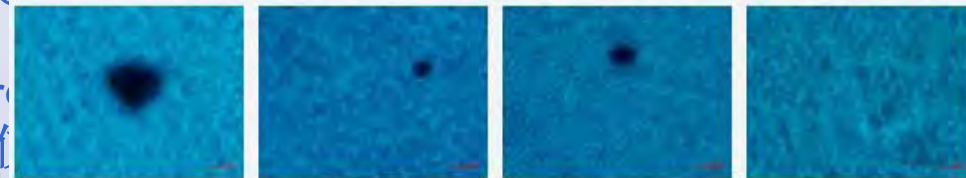
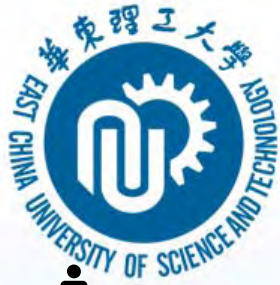


图2 不同硬脂酸锌用量的颜料分散照片

- Coupling agent prevents the agglomeration of pigment particles, decreases color aberration and enhances the weather resistance



研究进展 Research Progress



人造草丝

Artificial turf fiber

仿真

Simulation

颜色仿真

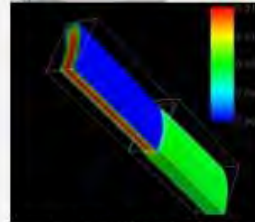
Color simulation

形状仿真

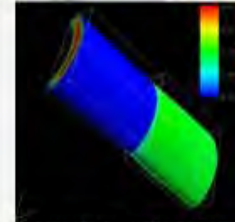
Shape simulation

气味仿真

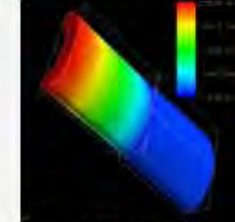
Smell simulation



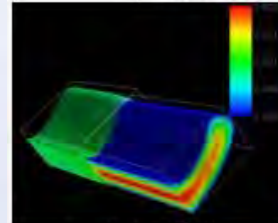
1/2 九十度扇形模拟
熔体速度图



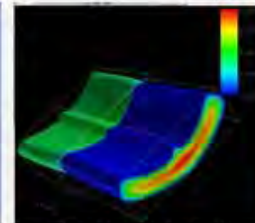
完整的九十度扇形
速度图



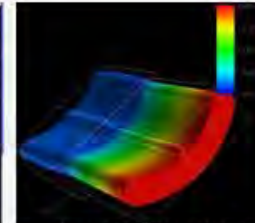
九十度扇形
压力图



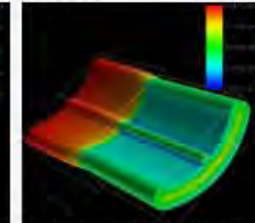
1/2 九十度扇形
加强筋速度图



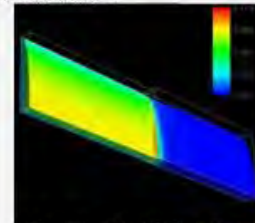
完整的九十度扇形
加强筋速度图



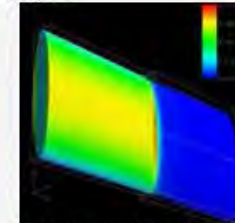
九十度扇形加强筋
压力图



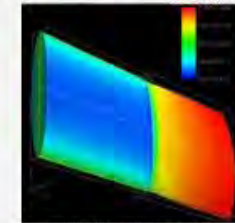
九十度扇形加强筋
黏度图



1/4 椭圆形剪切速率图



完整的椭圆剪切速率图



完整椭圆形黏度图





人造草丝

Artificial turf fiber

仿真

Simulation

颜色仿真

Color simulation

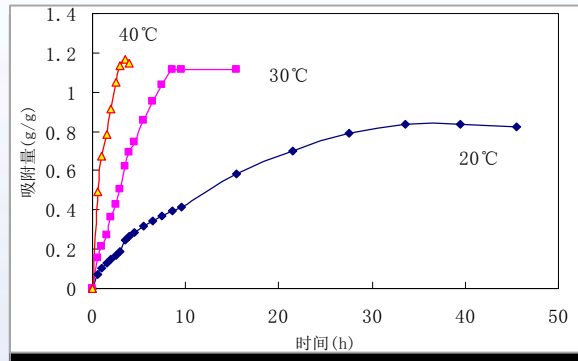
形状仿真

Shape simulation

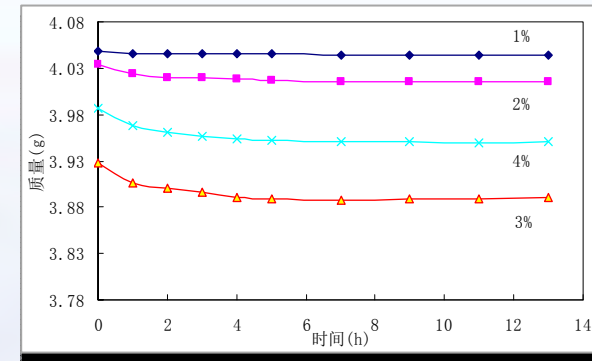
气味仿真

Smell simulation

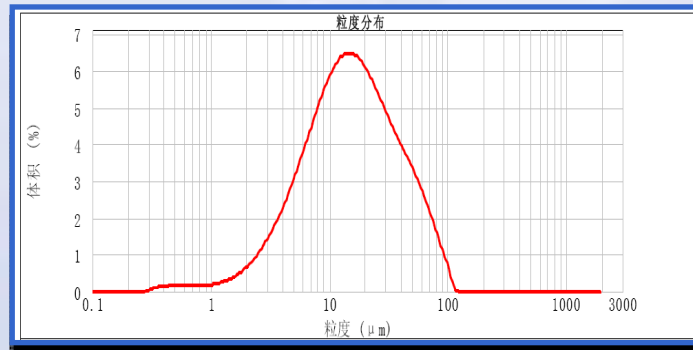
研究进展 Research Progress



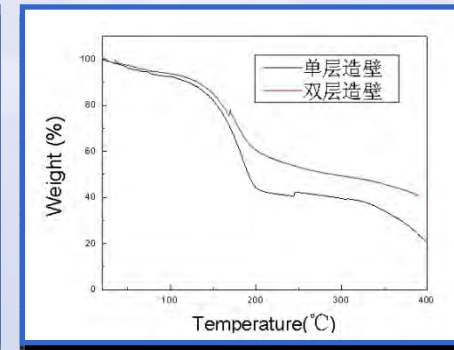
时间对吸附量的影响
Effect of time on adsorption amount



70°C下草丝的热失重
Turf fibre's weight loss at 70°C



微胶囊粒径分布
Particle size distribution of microcapsule



微胶囊稳定性
Thermal stability of microcapsule



研究进展 Research Progress

运动涂层 Sports surface coating

国内最早开展运动涂层防滑技术研究项目；首次引进涂层摩擦性能概念；国内唯一通过DIN标准检测的运动地面涂层；得到国家体育总局认可；为奥运会、大运会、世乒会、世博会服务。

Use nano-particle to modify the microscopic structure of the coating surface, and the friction coefficient is easily controlled, meeting the standard requirements of DIN18032-2:2001-04: 0.40-0.60.





研究进展 Research Progress

发泡材料 Foam Material

PP发泡流变学

Foaming rheology
of polypropylene

挤出发泡行为研究

Extrusion foaming
behavior

高回弹XPE发泡

Foaming of high
resilience XPE





研究进展 Research Progress

发泡材料 Foam Material

PP发泡流变学

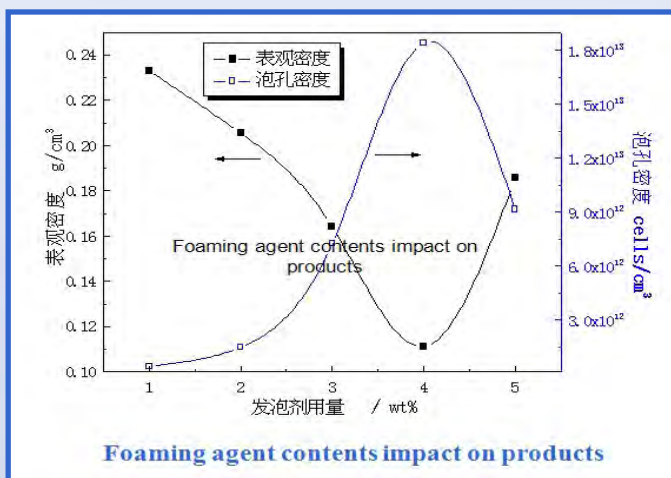
挤出发泡行为研究

高回弹XPE发泡

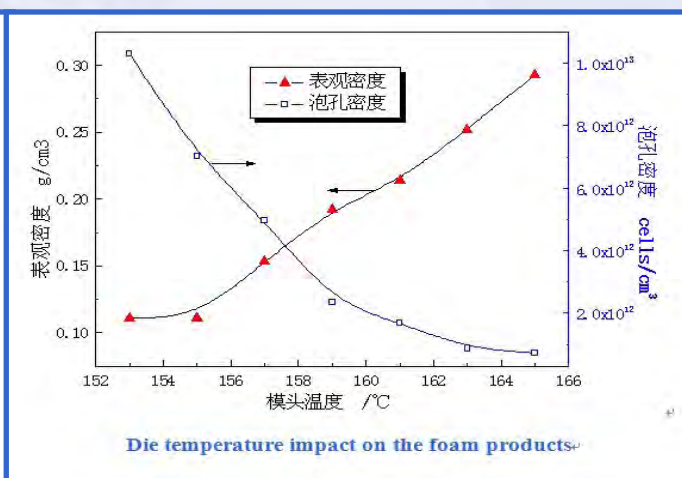
Foaming rheology of polypropylene

Extrusion foaming behavior

Foaming of high resilience XPE



Foaming agent contents impact on products



Die temperature impact on the foam products

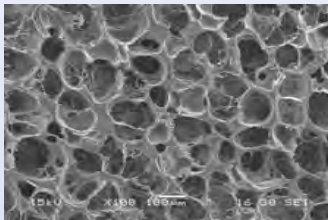


研究进展 Research Progress

发泡材料 Foam Material

PP发泡流变学

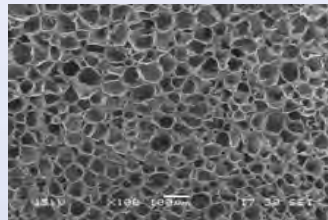
Foaming rheology
of polypropylene



$f=0$
 $A=0$

挤出发泡行为研究

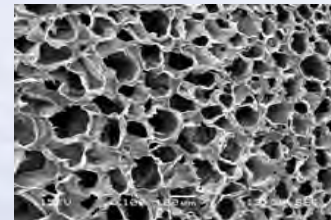
Extrusion foaming
behavior



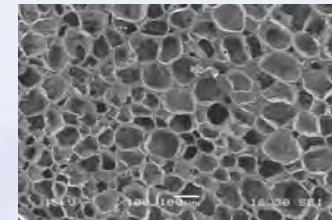
$f=5\text{Hz}$
 $A=0.25\text{ mm}$

高回弹XPE发泡

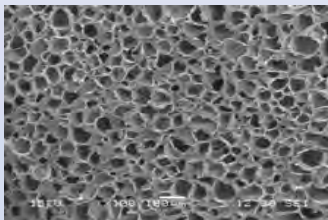
Foaming of high
resilience XPE



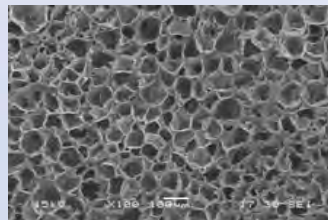
$f=10\text{Hz}$
 $A=0.05\text{ mm}$



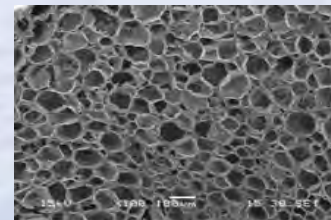
$f=10\text{Hz}$
 $A=0.10\text{mm}$



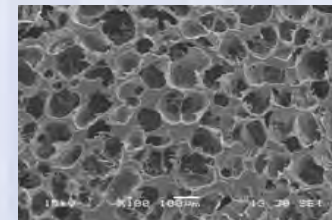
$f=10\text{Hz}$
 $A=0.20\text{mm}$



$f=10\text{Hz}$
 $A=0.25\text{mm}$



$f=15\text{Hz}$
 $A=0.25\text{mm}$



$f=25\text{Hz}$
 $A=0.25\text{mm}$

SEM photographs of foamed products under different oscillatory shear conditions



研究进展 Research Progress

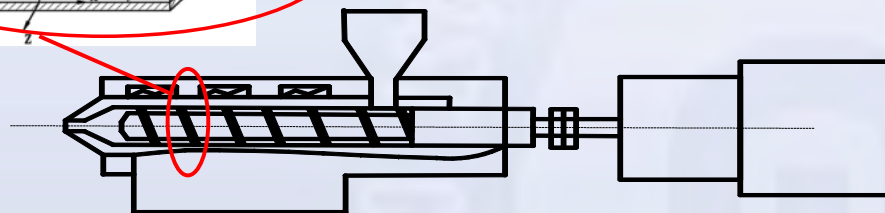
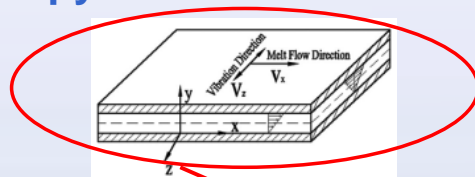
发泡材料 Foam Material



Foaming rheology of polypropylene

Extrusion foaming behavior

Foaming of high resilience XPE



Single screw 单螺杆 Oscillation unit 激振单元 主控单元 Master unit

- 剪切速率随脉动剪切力场振幅提高而提高，高振幅下，剪切速率增长趋势变大
Shear rate increases with oscillating amplitude increasing.
- 脉动剪切存在一个适宜剪切速率，超过该临界值后 (22S^{-1})，剪切对发泡不利

Shear rate higher than 22 S^{-1} is unfavorable for foaming.



研究进展 Research Progress

发泡材料 Foam Material

PP发泡流变学

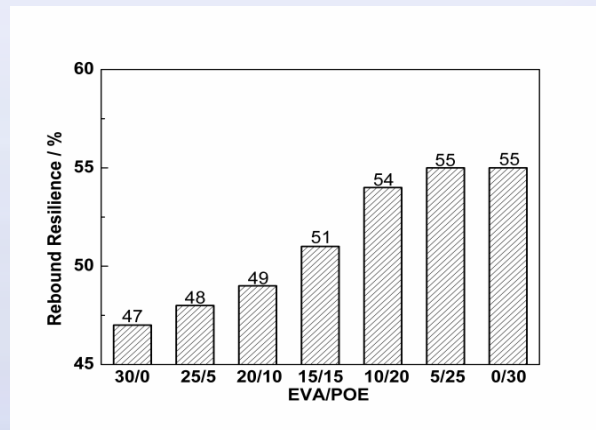
Foaming rheology
of polypropylene

挤出发泡行为研究

Extrusion foaming
behavior

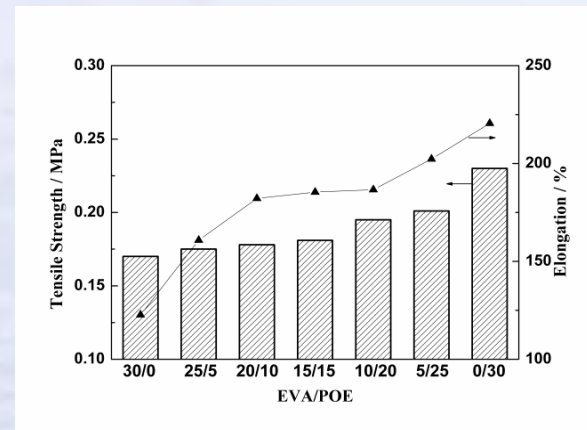
高回弹XPE发泡

Foaming of high
resilience XPE



不同配比下发泡片材
回弹率变化

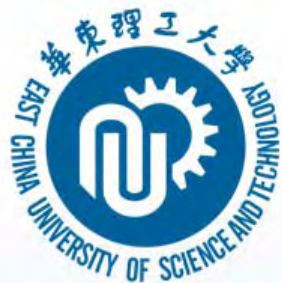
The variation in rebound resilience
of sheet with different formula



不同配比下发泡片材
拉伸强度与断裂伸长率

Tensile strength and breaking elongation
of foamed sheet with different formula



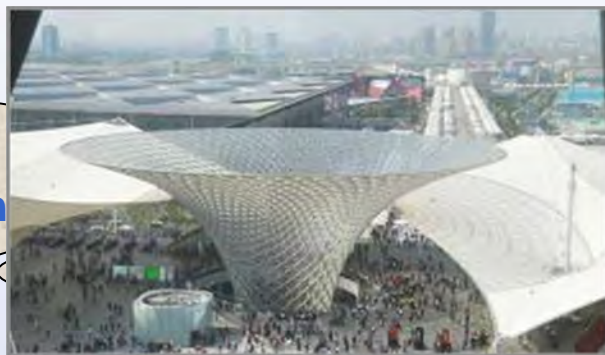


研究进展 Research Progress



地源热泵 Ground source heat pump

制冷
Refrigeration



地源热泵制冷
世博轴-冷
EXPO axis

制热
Heating



地源热泵制热
世博中心-
EXPO Center

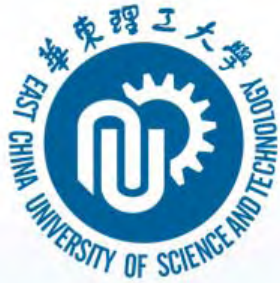


-演艺中心-
Performing Arts Center



-城市未来馆-
Future City Hall

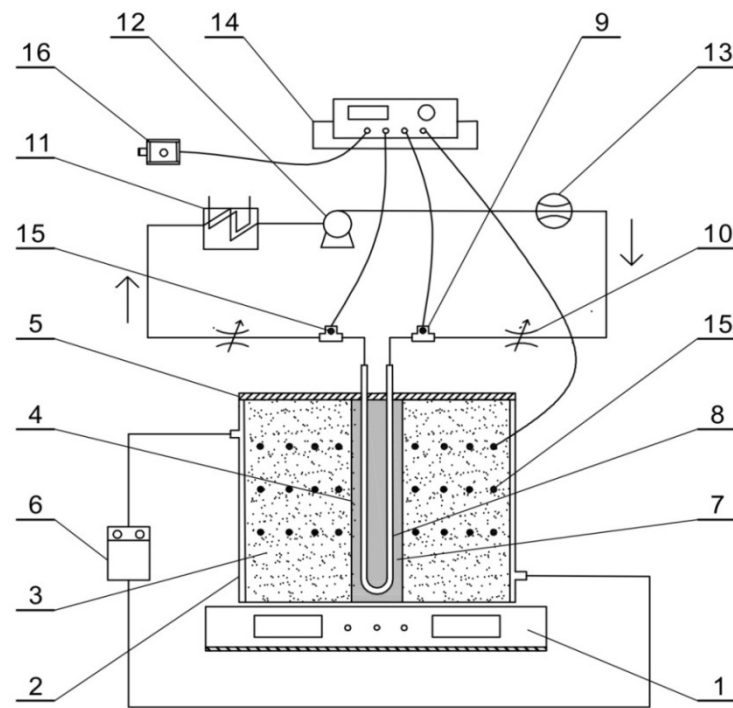
示意图
Illustration



研究进展 Research Progress



地源热泵 Ground source heat pump

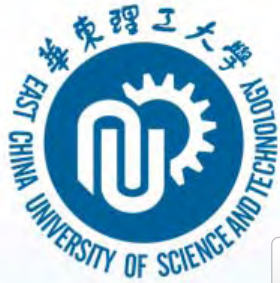


地源热泵模拟试验台

Simulation testing device for GSHP

- | | |
|-----------|----------------|
| (1) 地秤 | (9) 三通 |
| (2) 不锈钢套筒 | (10) 阀门 |
| (3) 土壤 | (11) 低温恒温槽 |
| (4) 钻孔 | (12) 自吸清水泵 |
| (5) 盖板 | (13) 流量计 |
| (6) 恒温水浴锅 | (14) 温湿度记录仪 |
| (7) 回填材料 | (15) PT100型热电阻 |
| (8) U形管 | (16) 温湿度变送器 |

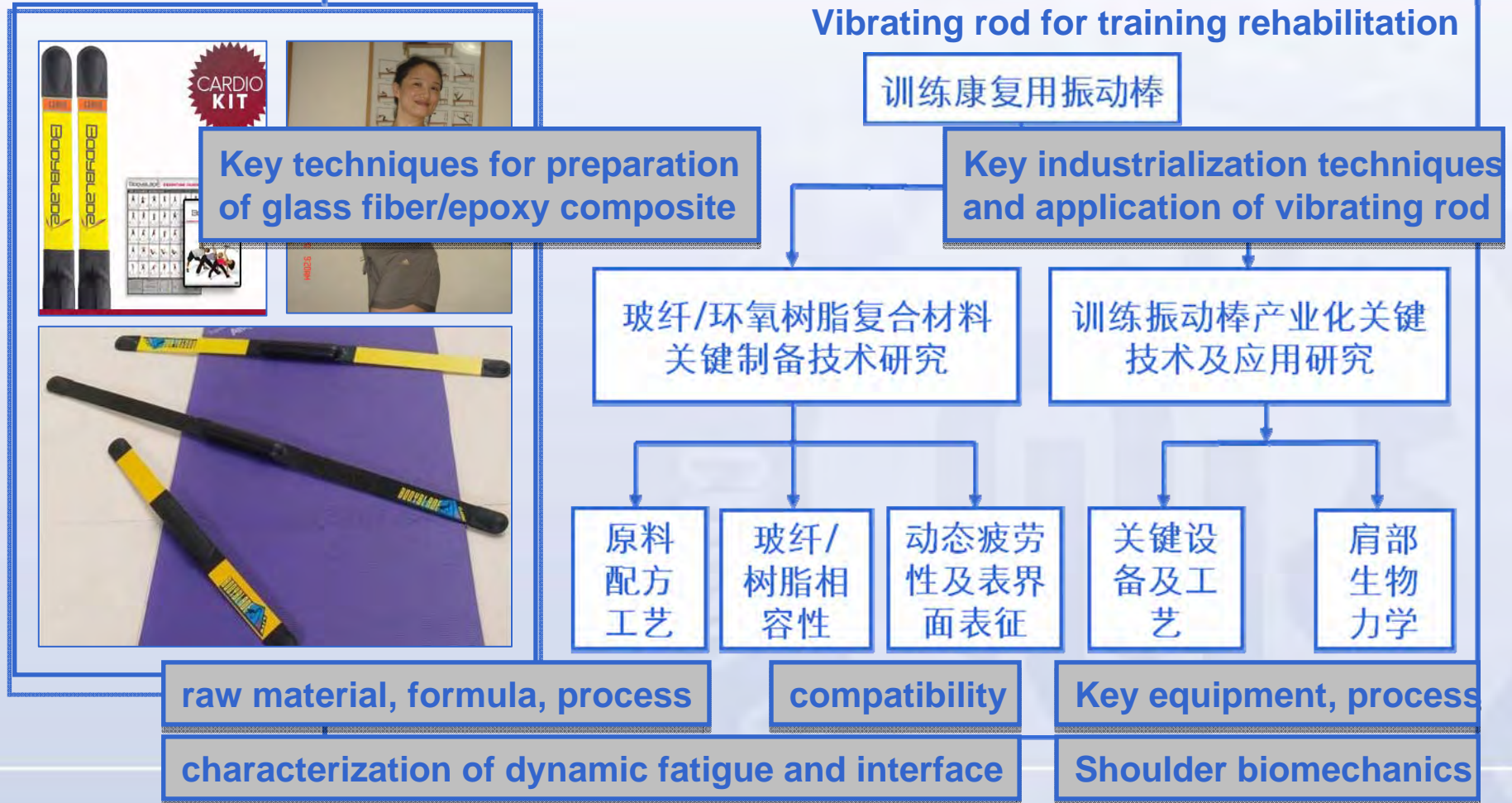




研究进展 Research Progress



康复器材 Rehabilitation equipment



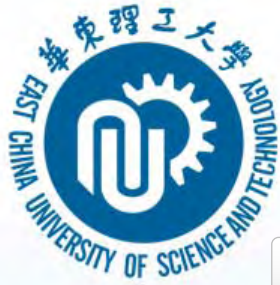
raw material, formula, process

compatibility

Key equipment, process

characterization of dynamic fatigue and interface

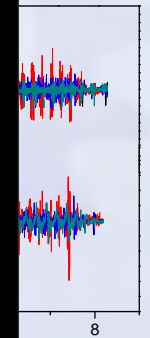
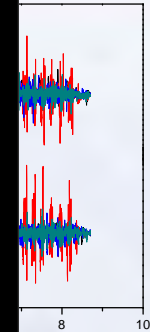
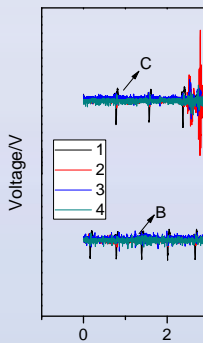
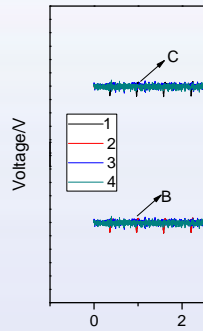
Shoulder biomechanics

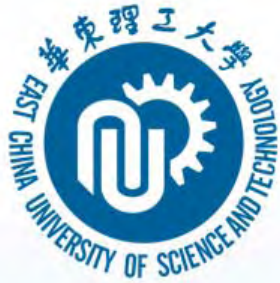


研究进展 Research Progress



康复器材 Rehabilitation equipment

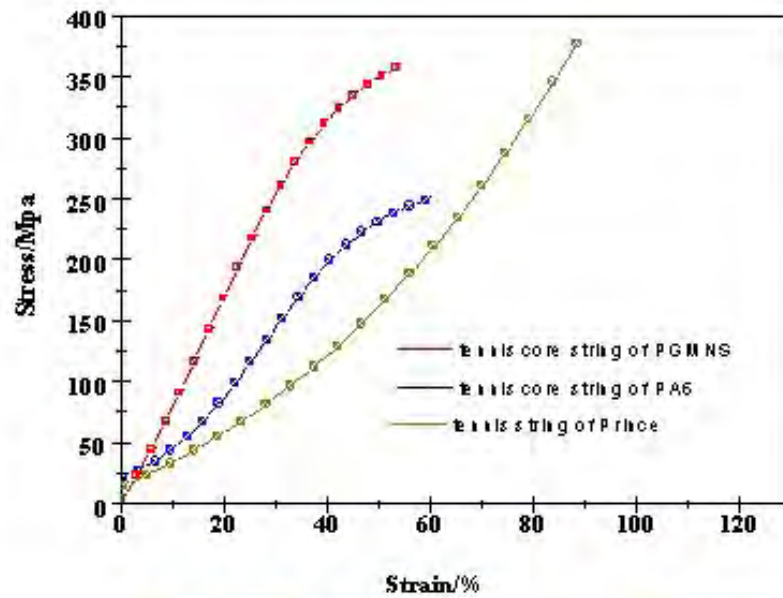




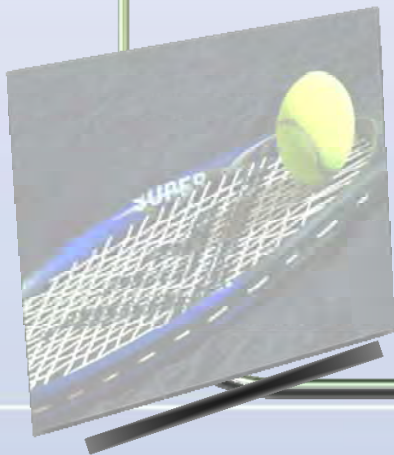
研究进展 Research Progress

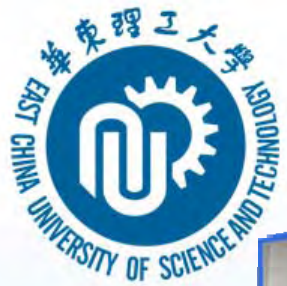


网球拍弦 Tennis racket strings



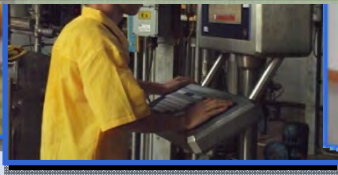
Single-filament tensile test





学术会议
Academic conference

技术交流
Technology exchange



研究生实习
Graduate internship

The image shows the main entrance of East China University of Science and Technology (ECUST). In the background, a large, modern stone gate structure features the university's name in Chinese characters, "華東理工大學". In the foreground, a large, dark red stone sign also displays the university's name in gold Chinese characters. The scene is set outdoors with trees and a cloudy sky.

華東理工大學

谢谢各位!

Thank you for your attention!

華東理工大學