

ARKEMA

PIEZOTECH®

ELECTROACTIVE POLYMERS  
FOR PRINTED ORGANIC ELECTRONICS



“

**We at Arkema are leaders in the production of a range of electroactive polymers: Piezotech®. These materials offer endless possibilities by enabling motion or thermal energy conversion into electricity and vice versa with the intrinsic advantages of polymers: processability, flexibility, lightness & low cost.”**

4

**FEATURES**

Piezoelectric, pyroelectric, high-k, and electrostrictive.



**PRINTABLE**

Wide range of high purity polymers and inks adapted to various printing techniques to obtain thin and homogenous layers.



**CUSTOMIZABLE**

Flexibility of Piezotech® products is paving the way for high degrees of liberty in terms of size, shape, number of sensing elements and substrates.



# 2 ranges of electroactive polymers

## Piezotech FC copolymers. Piezotech RT terpolymers.



**Thin, light and flexible, electroactive polymers can be processed by simple methods. Low energy cost, they offer an infinite number of possibilities.**

### - Piezotech FC copolymers **P(VDF-TrFE)**

**Highly crystalline copolymers with strong dipole orientation leading to unique electroactive properties:**



#### **Piezoelectric**

Conversion of mechanical energy (stress, strain) into electrical energy (voltage, current) and vice versa.



#### **Pyroelectric**

Conversion of thermal energy into electrical energy.

*PIEZOTECH® FC copolymers are ideal materials of choice for mechanical and thermal sensors, energy harvesting, actuators, speakers, memories.*

### - Piezotech RT terpolymers **P(VDF-TrFE-CTFE/CFE)**

**An additional monomer unit improves dipole mobility, thus inducing unique relaxor ferroelectric properties.**



#### **High-k**

High permittivity materials for flexible capacitors or thin film transistors.



#### **Electrostrictive**

High strain can be induced with an electrical field.

*PIEZOTECH® RT terpolymers are an excellent choice for high-k, dielectrics, actuators and electrocaloric devices.*

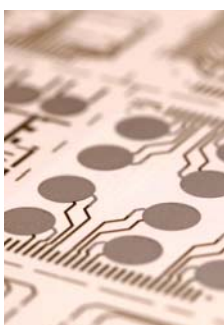
# High electronics performances with the intrinsic advantages of polymers.



## SENSORS

### PIEZOTECH® FC COPOLYMERS

Chemically & thermally stable materials (resistance to moisture, and to temperatures up to 120 °C) with high sensitivity over a **wide range of pressure** (mPa to GPa) **and frequency** (mHz to GHz). They exhibit excellent mechanical properties (high elastic modulus and flexibility) and transparency. Sensors fabricated from PIEZOTECH® FC copolymers enable the development of unique applications with detection through **touch, deformation, ultrasounds, heat, impact, acoustic waves**. Owing to the piezoelectric effect, sensors do not require an external power source.



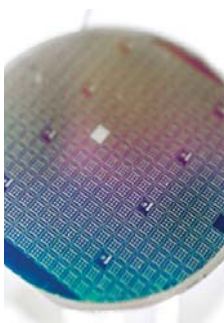
## ACTUATORS

### PIEZOTECH® FC COPOLYMERS

Due to the piezoelectric effect, strain is quickly induced on these materials when exposed to an electric field. Actuator performance is enabled by their **high energy density response**, even at low electric fields ( $< 50 \text{ V} \cdot \mu\text{m}^{-1}$ ).

### PIEZOTECH® RT TERPOLYMERS

Due to the electrostrictive effect, very **high strain** can be induced on these terpolymers, when exposed to electric fields ( $> 100 \text{ V} \cdot \mu\text{m}^{-1}$ ). Excellent actuator performance is enabled by their very high deformation rate.



## ORGANIC THIN FILM TRANSISTORS

### PIEZOTECH® RT TERPOLYMERS

Due to their **high relative permittivity** ( $> 30$ ), they provide optimum solutions for the design of Organic Thin Film Transistors (OTFT). The high-k gate dielectric layer allows for lower driving voltages and higher OTFT performances. The ability to solution process these materials at low temperature, allows for the use of low-cost conventional printing technologies.



## SOLID STATE COOLING

### PIEZOTECH® RT TERPOLYMERS

Thanks to their unique electrocaloric properties, they are an excellent choice for solid state cooling to enable new surface-conformable, compact, and **highly efficient cooling devices**. Solid-state cooling systems have recently emerged as promising alternatives that eliminate the need for compressors and conventional liquid or vapor refrigerants.

“

Through many applications (force/shock/temperature sensors, actuators, energy monitors ...), Piezotech® materials address markets such as medical, structural health monitoring, smart surfaces (smart floor, human-machine interfaces, in mold electronics etc.).”

# Materials for the conquest of expanding and innovative markets.



### A RICH ECOSYSTEM

Arkema is the driving force behind an ecosystem that brings together manufacturers, universities and start-ups to help move from materials to a final product



### LOW ENERGY USE

Recyclable and self-generating, Piezotech® polymers pave the way for more sustainable and responsible electronics.

### Human-machine/object interfaces



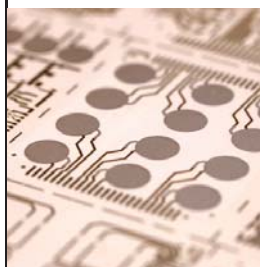
Piezotech® materials find their place in HMI or smart surfaces for equipping floors or dashboards to detect a fall, track movements etc.

### Haptics



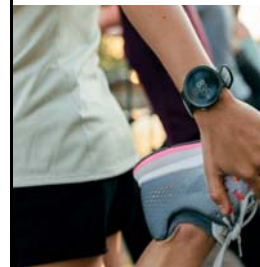
Embedded in gloves, joysticks, surfaces etc. the materials can create haptic tactile illusions for total user immersion.

### Printed speakers



The printing of Piezotech® materials makes it possible to produce loudspeakers on a large surface, while being flexible and light.

### Vital signals monitoring



To measure pulse, respiration, stress, pressure and sleep, Piezotech® materials can be integrated into wristbands, mattresses, fabrics etc.

Based on the excellent acoustic properties of Piezotech® products, structural changes or aging of H<sub>2</sub> tanks, batteries, wind turbines can be monitored etc.

### Structural health monitoring



### Electro-caloric devices & energy harvesting



Through the piezo properties energy harvesters can be designed while their unique electrocaloric properties make them the materials of choice for solid state cooling.

# PIEZOTECH®

## Powders



Typical properties are only given as indicative values, not specifications.

Electroactive performances strongly depend on processing and operating conditions.

Specific product composition or MFI are available on demand.

Product name Polymer base Grade	Piezoelectric				Electrostrictive and High-k		
	Piezotech® FC				Piezotech® RT		
	P(VDF-TrFE) Copolymer				P(VDF-TrFE-CTFE/CFE) Terpolymer		
	FC 20	FC 25	FC 30	FC 45	RT-TS	RT-FS	
	<b>Composition (mol%)</b>						
	% TrFE				% CTFE	% CFE	
1H & 19F NMR	20	25	30	45	Standard Composition		
	<b>Indicative Thermal Properties</b>						
<b>Melting Point (°C)</b> Second heating by DSC ASTM D3418	150	150	151	158	122	127	
<b>Curie Transition (°C)</b>	136	115	100	60	-	-	
	<b>Indicative Molar Mass</b>						
<b>Mw (kg.mol<sup>-1</sup>)</b> SEC in DMSO PMMA eq		450				500	
<b>MFI</b> ASTM D1238 230°C under 10 kg		1-6					
	<b>Indicative Dielectric Properties</b>						
$\epsilon_r$ Capacity measurement at 1 kHz	9 - 12		10 - 14		40	55	
<b>Saturation Polarization (mC.m<sup>-2</sup>)</b>	-	-	-	-	55	60	
<b>Remnant Polarization (mC.m<sup>-2</sup>)</b> At 150 V.µm <sup>-1</sup>	85	70	65	45	-	-	
<b>Coercive Field (V.µm<sup>-1</sup>)</b>	45	50	50	55	-	-	
	<b>Indicative Piezoelectric / Pyroelectric properties</b>						
<b>d33 (pC.N<sup>-1</sup>)</b> Piezotest PM300 1 N, 110 Hz	-24 to -30		-18 to -22		-	-	
<b>Typical P3 (µC/m<sup>2</sup>/K)</b> Literature	-30		-50		-	-	
	<b>Indicative mechanical and optical properties</b>						
<b>Storage Modulus E' (GPa)</b> ASTM D638	0.8 - 2.8				0.2 - 0.4		
<b>Transmittance (%)</b> ASTM D1003	>96%				>99%		

# A wide range of polymers to meet each of your applications.

We have formulated electroactive inks with various viscosities and dry contents to process our polymers via your routine printing techniques: screen printing, spin-coating, solvent-casting, slot-die coating, ink-jet printing and roll-to-roll process.

## Inks



Specific ink formulations can be developed upon request to fit your printing process.

Grade	Printing Technology	Viscosity (mPa.s at 32°C)	Thickness range (um)
<b>Ink I</b>	Ink-jet	< 20	0,05 - 2
<b>Ink L</b>	Spin-coating Slot-Die	< 1000	0,1 - 2
<b>Ink H</b>	Spin-coating Solvent-casting	1500 - 3000	Spin-coat: 0.5 - 2 Solvent-cast: 2-80
<b>Ink P</b>	Screen-printing	20000 - 24000	1 - 20

The four ink grades are available in two ranges depending on the properties required: FC ink and RT ink. The expected properties are given as an indication.

	Piezo/pyroelectric FC ink	Electrostrictive and high-k RT ink
<b>Polymer</b>	FC 20	RT-TS
<b>Melting temp rage (°C)</b>	148 - 151	115 - 130
<b>Annealing temp range(°C)</b>	140 - 145	105 - 120
<b>Curie temp range (°C)</b>	128 - 140	-

FC and RT polymers dissolve in many solvents. With Arkema's expertise, we can help you formulate your customized inks by guiding you through the solvent selection and processing steps.



**Piezotech Arkema**

Arkema-CRRA  
Rue Henri Moissan  
69496 Pierre-Benite Cedex  
FRANCE

info.piezotech@arkema.com  
Phone: +33 4 72 39 87 03  
www.piezotech.arkema.com



**Headquarters: Arkema France**

420 rue d'Estienne d'Orves  
92705 Colombes Cedex  
France  
T +33 (0)1 49 00 80 80

Disclaimer - Please consult Arkema's disclaimer regarding the use of Arkema's products on <https://www.arkema.com/global/en/products/product-safety/disclaimer/>

Arkema France, a French *société anonyme* registered at the Trade and Companies Register of Nanterre under the number 319 632 790

[arkema.com](https://www.arkema.com)

**ARKEMA**