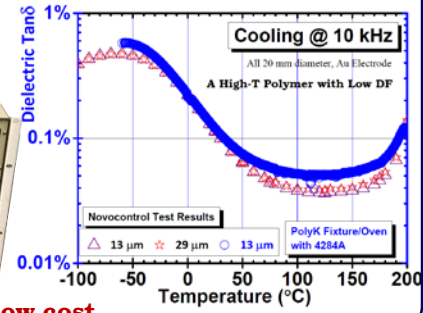
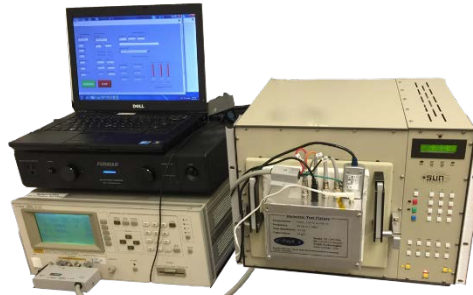


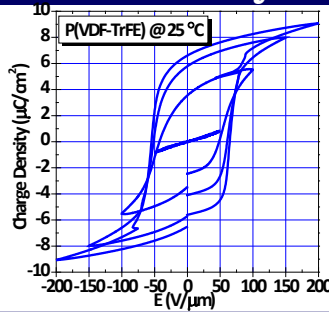
Low-Cost Turnkey Dielectric Test System

Capacitance [dielectric constant] and **loss $\tan\delta$** vs. frequency and temperature: Integrate Agilent 4284A (E4980A) Precision LCR meter with Sun chamber (w/ liquid nitrogen cooling) with LabView Control Program. Multiple specimens. Up to 250 °C, DF accuracy < 0.1%. **Cost < \$25K**



Modular design: Can expand to TSDC with Low cost

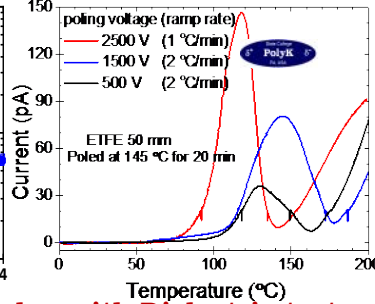
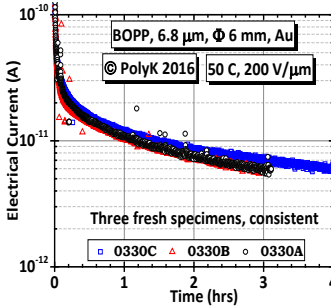
Polarization Loop & Dielectric Breakdown Test System



Including a used Trek amplifier for < \$9,999. Sample test fixture for soft polymer films. Software can directly provide charged and discharged energy density, and perform lifetime test with a summary file of energy density vs. test cycles.

High Voltage Leakage Current, TSDC, & Pyroelectric

- Test voltage > 10 kv
- Temperature: -150 °C to 300 °C
- High sensitivity, leakage current accuracy < 1 pA
- Integration of multi-mode measurements: TSDC, pyroelectric & leakage current
- Spring-loaded electrode to maintain a necessary minimum force to avoid damage to thin or soft specimen

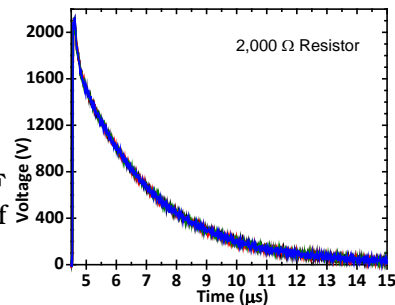


Modular design: share chamber with Dielectric test system

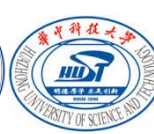
Capacitor Charge-Discharge Test System



- Directly measure the discharge speed and energy of capacitor samples at speed of 100 ns
- Voltage > 15 kV
- Capacitance: 10 pF to > 1 mF
- Computer control, capable of life-time cycle test



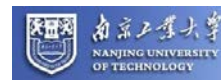
Current Customers PENNSTATE



Georgia Tech



จุฬาลงกรณ์มหาวิทยาลัย
Chulalongkorn University



Piezoelectric, Ferroelectric, Pyroelectric & Electroactive Polymer Kit: P(VDF-TrFE)

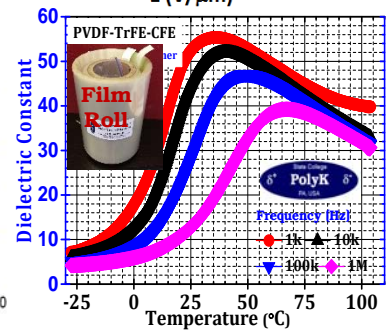
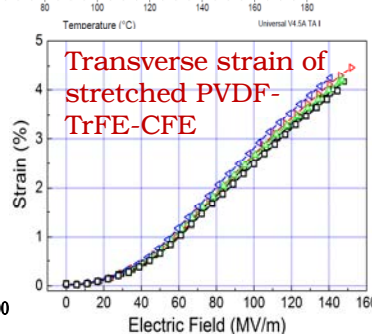
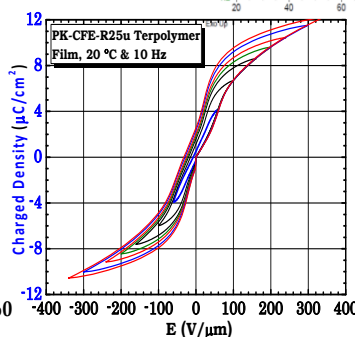
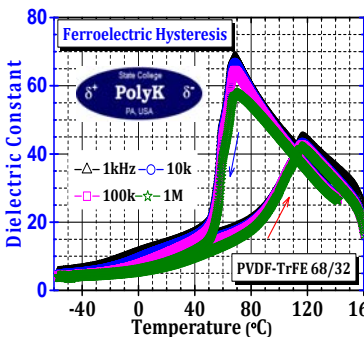
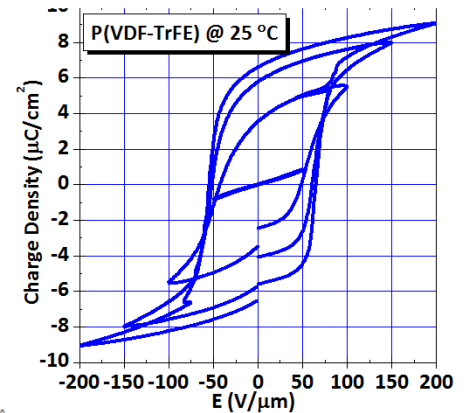
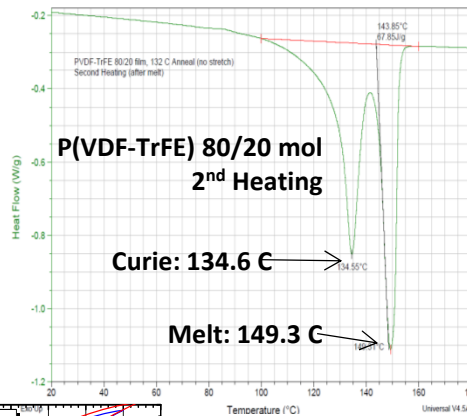
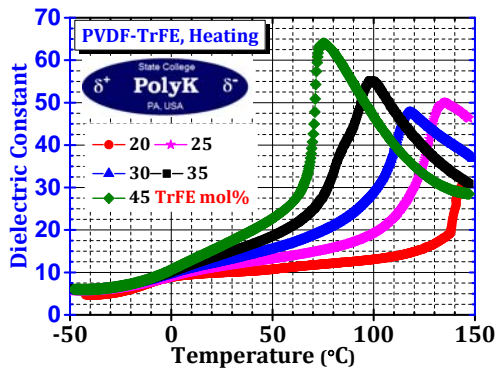
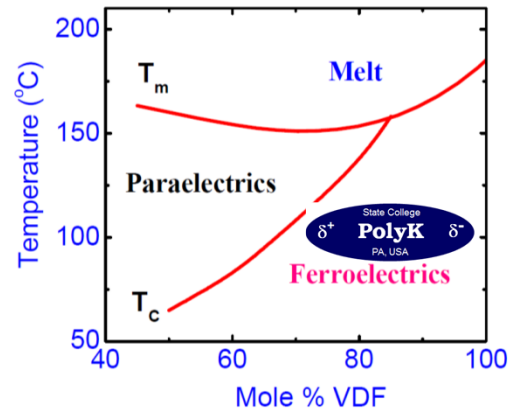
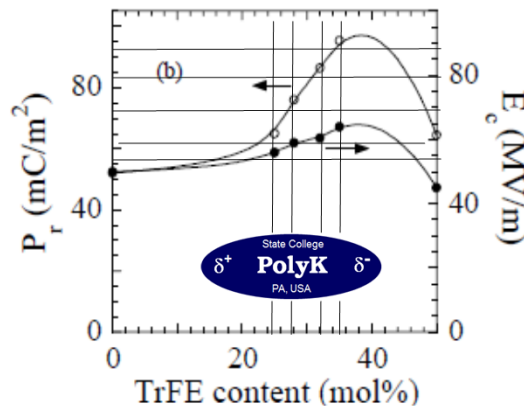
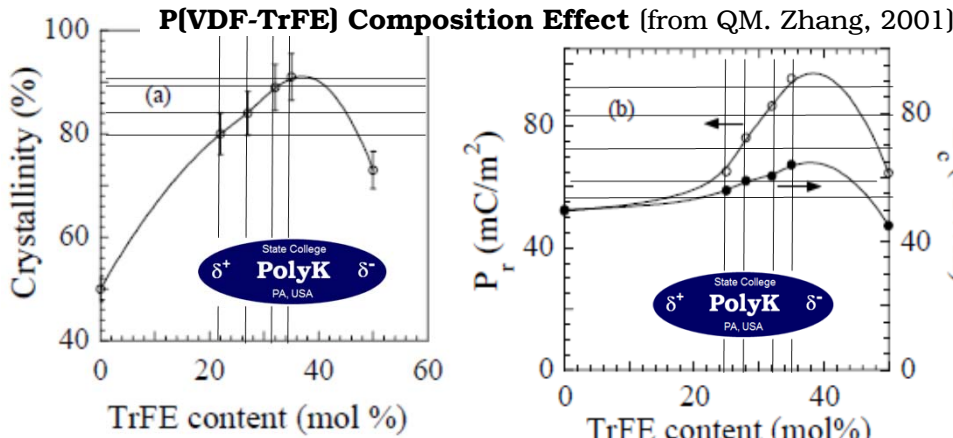
For R&D in high energy density capacitor, piezoelectric, pyroelectric, electrocaloric ECE, & electroactive polymer EAP. Include **20 grams** of each of **Seven** typical polymer resins based on P(VDF-TrFE).

1. P(VDF-TrFE) 80/20 (mol), Curie: 135 °C
2. P(VDF-TrFE) 75/25 (mol), Curie: 112-121 °C
3. P(VDF-TrFE) 70/30 (mol), Curie: 104 °C
4. P(VDF-TrFE) 65/35 (mol), Curie: 72 °C
5. P(VDF-TrFE) 55/45 (mol), Curie: 66 °C
6. P(VDF-TrFE-CFE) Terpolymer 63/30/7 (mol), T_m : 130 °C. Ferrorelaxor polymer with high dielectric constant ~60 at 25 °C.
7. P(VDF-TrFE-CTFE) Terpolymer 65/31/4 (mol), T_m : 130 °C. Ferrorelaxor polymer with high K~60 at 50 °C and 1 kHz.

Other compositions available upon request

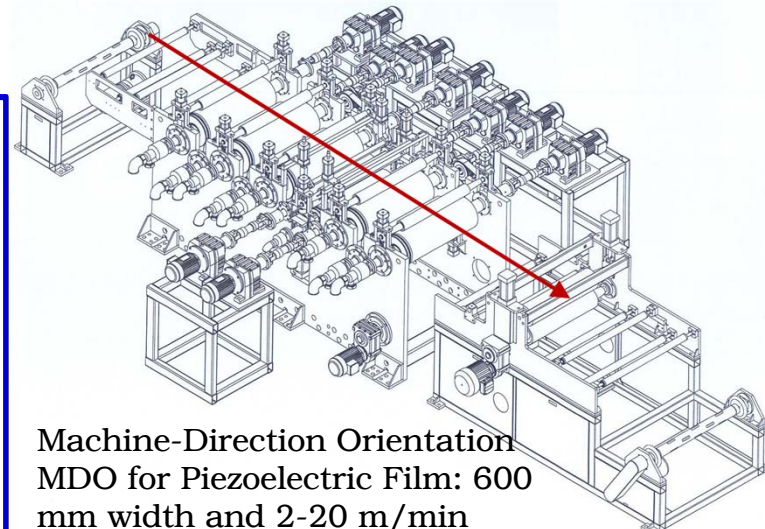
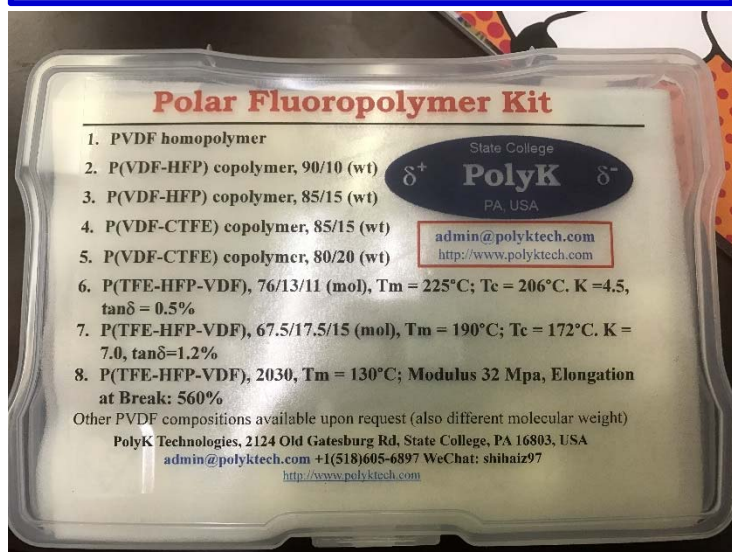
Poly(vinylidene fluoride-co-trifluoroethylene) copolymers & terpolymers (CFE, CTFE)

US Supplier



Dielectric Polymer Kit: PVDF-Based Polar Fluoropolymers

Polymer kit for R&D in capacitor, piezoelectric, pyroelectric, electrocaloric ECE, & electroactive polymer EAP. Include **20 grams** of each of **Eight** typical polymer resins based on PVDF.



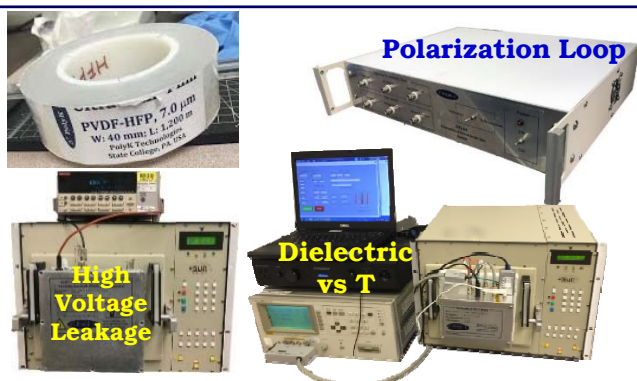
Machine-Direction Orientation
MDO for Piezoelectric Film: 600 mm width and 2-20 m/min



- Other PVDF compositions also available
- PVDF homopolymers with different molecular weight: ultra-low MW for electrospinning and ultra-high MW for battery binders
- PVDF-based polymers from Solvay (SOLEF), Arkema (Kynar), 3M (Dyneon), Kureha, China
- TFE-VDF based copolymers with high melting temperature and high dielectric constant
- Small quantity of 20 g to large quantity of 5 kg: commercial products with high quality
- Film based on PVDF: solvent cast, extruded, uniaxial orientation, biaxial orientation, poling, metallized
- Film thickness: 2 μm to >100 μm
- PVDF piezoelectric film and actuator film (beta phase film)

Dielectric, Piezoelectric R&D

- Polymers: fluoropolymers of VDF with over 20 compositions & molecular weight
- Films: solvent cast, extrusion, poled, electrode, 1-100 μm
- Low-Cost Test Equipment: polarization loop, dielectric constant vs temperature & frequency, leakage current
- Device: piezoelectric sensors, capacitors, actuators, etc



PolyK has a unique collection of ultrathin dielectric films and resins for R&D in capacitors, batteries, printed electronics, wearable electronics, OLED, photovoltaics, acoustics, electro-wetting, speakers, actuators, sensors, etc. Examples include:

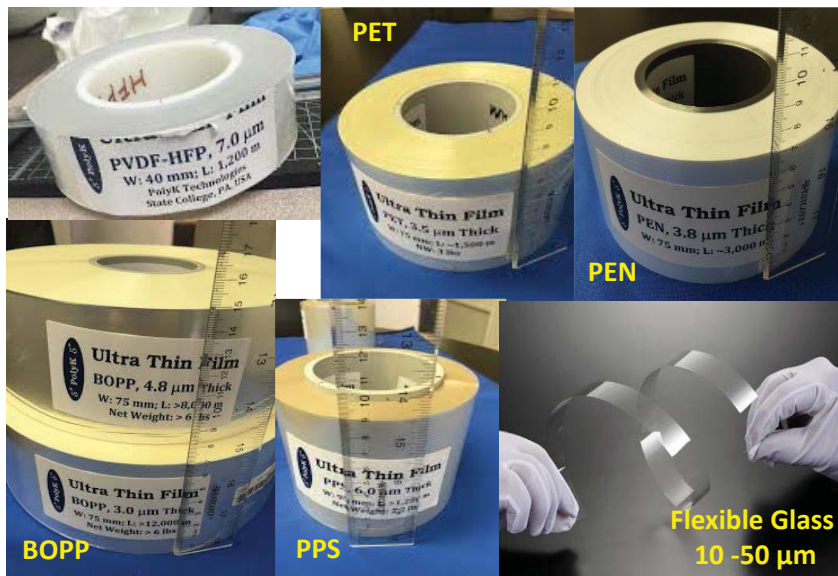
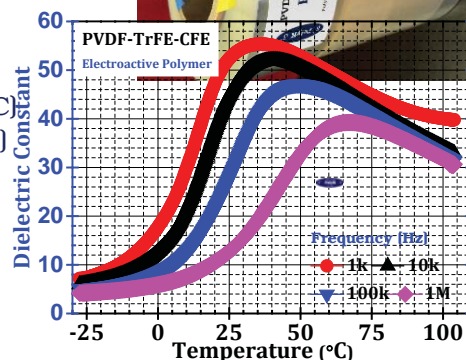
1. Biaxially oriented polypropylene (BOPP): 2.0 μm , 2.4 μm , 3.0 μm , 3.5 μm , 3.8 μm , 4.8 μm , 5.8 μm , 6.8 μm , 7.8 μm , 9.8 μm , 15 μm .
2. Biaxially oriented polyethylene terephthalate PET): 1.4 μm , 2.0 μm , 3.5 μm , 4 μm , 6 μm
3. Biaxially-oriented polyethylene-naphthalate (PEN): 2.4 μm , 3.8 μm , 5 μm , 6 μm
4. Biaxially-oriented polyphenylene sulfide (PPS): 4.5 μm , 6 μm , 9 μm
5. Biaxially-oriented Poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) and PVDF: 2.0 μm , 3.0 μm , 4.0 μm , 4.8 μm , 6.2 μm , 8.0 μm , 10 μm
6. Ferroelectric poly(vinylidene fluoride-co-trifluoroethylene) (PVDF-TrFE or PVDF-VF3): 5 μm , 21 μm , and other thickness (also with polymer resin)
7. Electroactive polymers: P(VDF-TrFE-CFE) and P(VDF-TrFE-CTFE) with $K > 40$
8. Extruded PVDF and PVDF-HFP film (no orientation): from $< 25 \mu\text{m}$ to $> 100 \mu\text{m}$
9. Extruded PP film without orientation: any thickness above 15 μm
10. Polycarbonate films ($< 10 \mu\text{m}$)
11. Polyetheretherketone (PEEK) film: 9 μm and 12 μm
12. Polyetherimide (Ultem 1000) film: 6 μm , 12 μm
13. High temperature polyetherimide polymers and films (T_g from 225 C to 265 C)
14. Polyethersulfone (PESU) and polyphenyl sulfone (PPSU): film (6 μm to 25 μm)
15. Fluorene polyester (FPE) film: 6 μm (and polymer powders, T_g 330 deg C)
16. Soluble polyimide Matrimide 5218: $T_g \sim 325 \text{ C}$ (NO imidization required)
17. Flexible glass: 10 μm , 25 μm , and 50 μm , dielectric constant of 5.5
18. Polymer resins of the above films and capability to produce other films.
19. Machine-direction oriented polymer film with our own MDO machine.
20. Most commercial fluoropolymer resins (Solvay, Arkema, Daikin, 3M, Kureha)



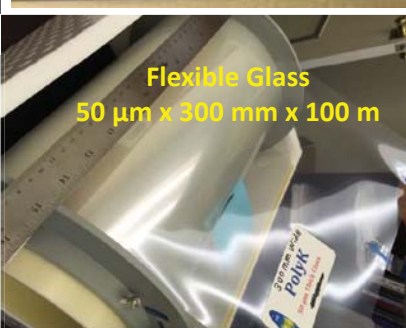
1.4 μm PET



PVDF-TrFE-CFE High K ~50



PEEK Film



Flexible Glass 50 μm x 300 mm x 100 m



PVDF-TrFE Ferroelectric

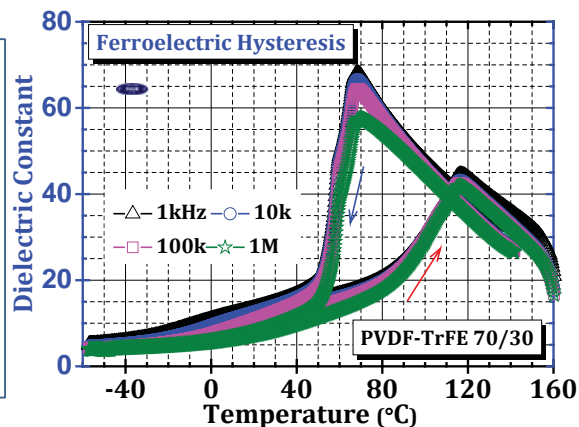
Test Capability

Polymer/Film

- TA Q2000 Modulated DSC
- TA Q800 DMA with LN2
- Nicolet FTIR with polarizer
- Thermal Conductivity
- MTI Folding Test
- Environment Chamber (-50 to 200 C, with RH control)

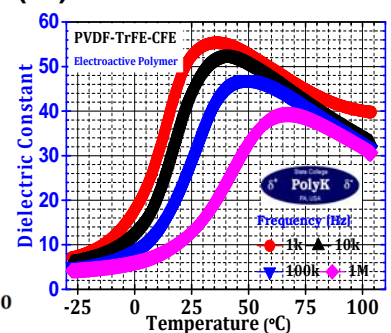
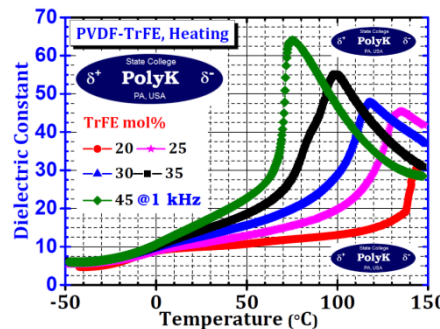
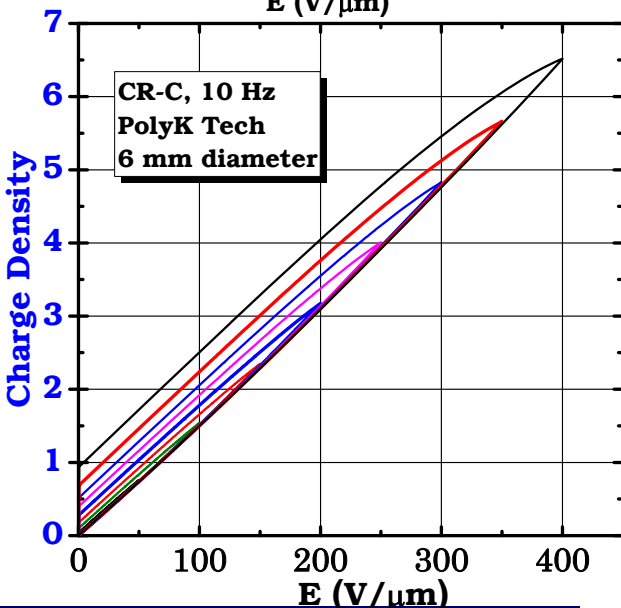
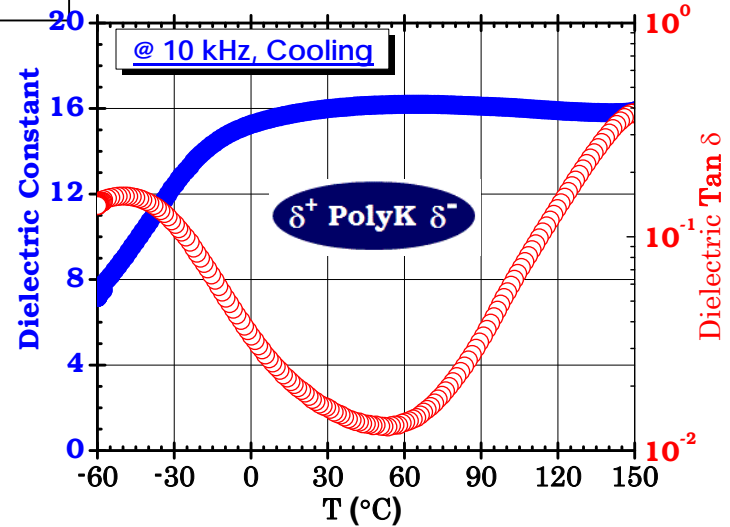
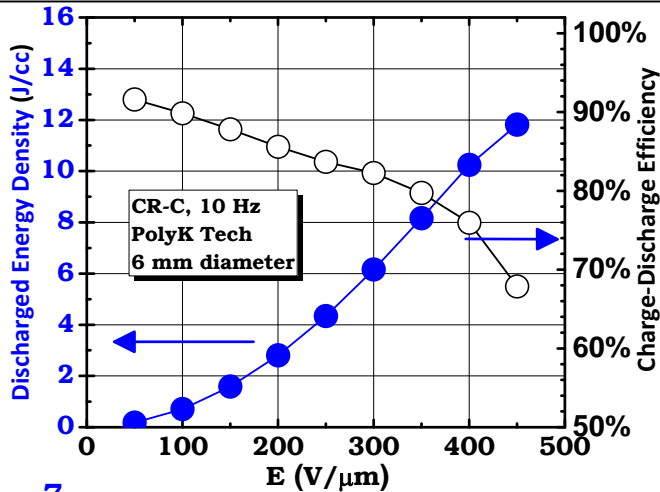
Special

- Electrode Deposition: sputtering (Au, Ag, Pt), evaporation (Al, Au)
- High voltage dielectric and polarization test vs T and F
- Piezoelectric: charge d_{33} & d_{31}
- Energy harvesting 100 lb shaker
- Laser, diamond wire saw cutting



High Dielectric Constant Cyanoethylated Cellulose CR-C

1. Thermoplastic with high K of 16
2. Unlike PVDF, CR-C is linear dielectric and it does not have polarization saturation, therefore offer higher energy density for capacitor energy storage.
3. Soluble in DMF, MEK, Acetone, and easy to prepare thin film and nanocomposites in lab scale.
4. CR-C has the best mechanical and high voltage performance than other compositions.



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- Films: solvent cast, extrusion, poled, electrode, 1-100 μm
- Low-Cost Test Equipment: polarization loop, dielectric constant vs temperature & frequency, leakage current
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