Durable, low-voltage electroactive polymers formed from polyionic complexes

Caltech

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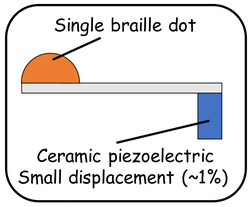
A novel electro-responsive material to bring braille into the modern era

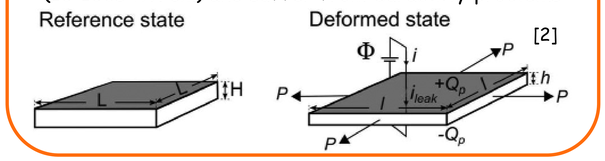
Refreshable braille displays are of paramount importance for learning sophisticated ideas

Commercially available devices are complex to engineer as they rely on piezoelectric crystals and levers

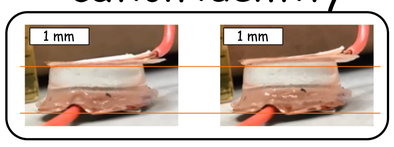


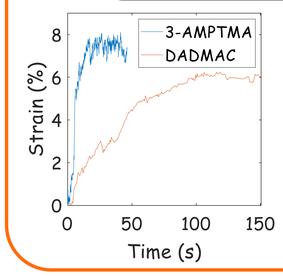
Work to replace them with electroactive polymers (EAPs) is ongoing

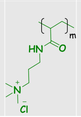
Previously reported EAPs require strong electric fields (10-100s kV/cm) and suffer from durability problems



Expansion rate is sensitive to cation identity





Polycation	Structure	Tg (C)	Response time (s)	Swelling (strain)
Poly(DADMAC)		~150	90	6%
Poly(3-AMPTMA)		~20	10	7%

References and Acknowledgements

[1] https://en.wikipedia.org/wiki/Refreshable_braille_display
[2] Choon Chiang Foo, et. al. ***Journal of Applied Physics*** 111 (9), 094107 (2012).
[3] Image courtesy of Rebecca Gallivan

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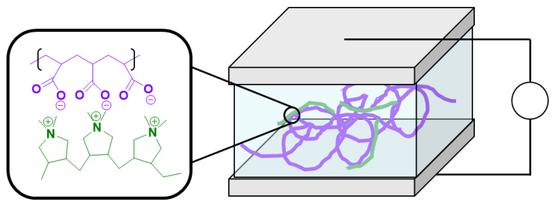
Oppositely charged polyions expand and contract in response to an electric field

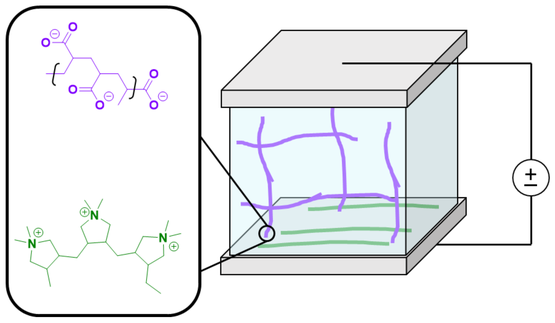
No electric field:

Polymer chains driven together and coiled



Applied electric field:

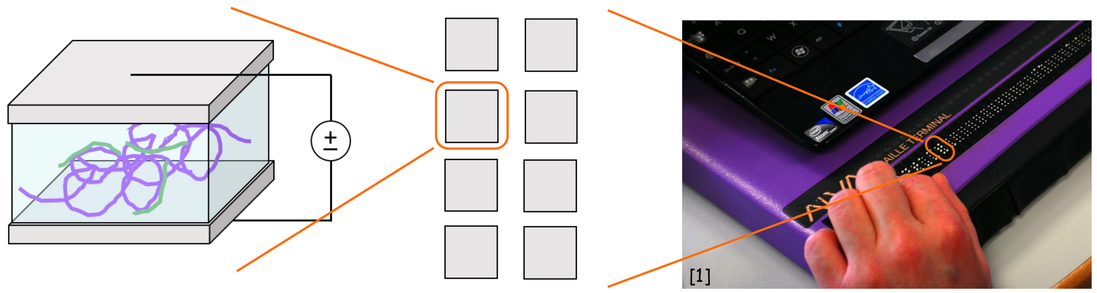
Oppositely charged polymers driven apart, Charged repeat units repel one another, resulting in gel swelling



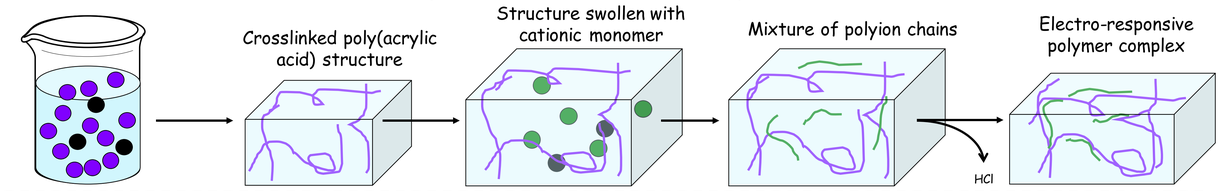
Single polymer actuator (side view)

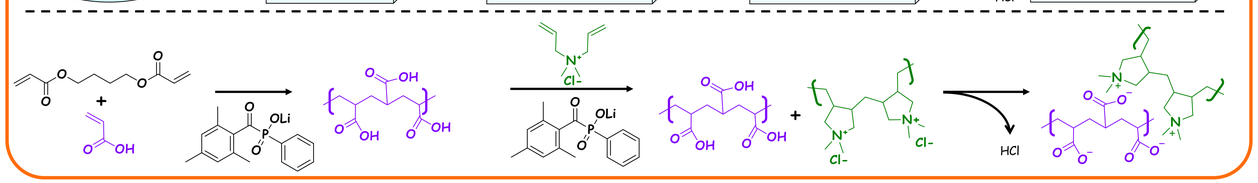
Refreshable braille character (top down)

Refreshable braille display



Example of material synthesis

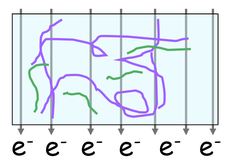




Expansion is driven by electrostatic interactions

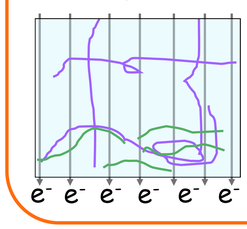
Neutral state: ionic groups form transient crosslinks between polymer chains

Electric field applied



Transient crosslinks dissociate due to electric field, polycations migrate towards negative plate

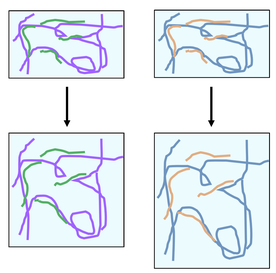
A few seconds elapse



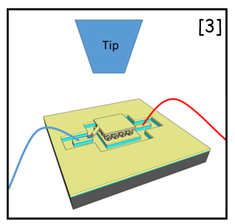
Charged repeat units are exposed, chains elongate due to electrostatic repulsion; gel expands

Research is ongoing

Increase degree of swelling response



Test cyclability of material to 1000s of cycles



Assess changes in mechanical properties and self-healing capacity between neutral and swollen state