ESR2. Synthesis and use of novel functionalised materials

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ESR2. Synthesis and use of novel functionalised materials

Host Institution: Dublin City University

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Insight

Adaptive Sensors Group

NCSR
National Centre for Sensor Research
WP 1: Materials, Processes and Technologies for organic bioelectronics
  ➢ WP2, WP3, WP4

Main Objective

• Design, synthesis, development and deposition of materials for organic bioelectronics.

This includes: synthesis and use of novel functionalised materials, synthesis and supply of new polymer materials, organic semiconductor based on solutions, nanomaterials for production of nanodevices with a diagnostic role. Compatibility with devices and large scale manufacturing techniques will be considered.

Task 1A. Novel organic materials and polymers (POLYMAT, DCU, UNIBA)

• Testing and integration of light activated polymer valves (DCU).
• Development of nanostructured conducting polymers and nanocomposites (POLYMAT, DCU).
• Development and provision of biocompatible organic ionogels (DCU).
1. Testing and integration of light activated polymer valves

- Less hydrophilic
- More hydrophilic

Spontaneous in H₂O

White light

Fig. 2 shows the results of photoinduced shrinking experiments performed on gels containing 1% BSP and 0 to 5% AA. The rate of shrinking in the blank poly(NIPAM) gels occurs. In fact, the temperature rose from the initial 18°C during the 20 min period of measurement. Therefore, shrinking of gels containing 1% spiropyran and varying amounts of AA into these gels simplifies the actuator operation by removing the need to use an external HCl bathing solution to prime the gel prior to photo-induced shrinking.

Shrinking of gels containing 1% spiropyran and varying amounts of AA content in the gel formulation will increase the rate and extent of conversion of MC to BSP on its own. This suggests that the spontaneous formation of MC-H⁺ upon irradiation with white light results in a small degree of heating of the gel because the light source used to actuate the gels, although a cold LED source, induces a small degree of heating of the gel. However, the results in Table 2 show that all gels with 1% BSP contain any BSP (Fig. 2). However, samples from the same batch which were equilibrated in HCl (30% v/v) pre-soaked in 1 mM HCl exhibit a yellow colour characteristic of the protonated MC form (MC-H⁺) rather than the deprotonated MC form (MC-H⁻). Therefore, increasing the BSP content in the formulation (see Table 1) will increase the rate and extent of induction of deprotonation of the MC-H⁺ groups. A schematic representation of the proton exchange taking place in the gels is shown in Fig. 3.

Another optimisation aspect of these gels is the reswelling extent of the photo-induced actuation efficiency of light. This is inherent to the shrinking mechanism. However, the results in Fig. 4 suggest that there is an optimum BSP content of 1% for these gels, and this value is also shown to shrink slightly even at temperatures several degrees below the actual LCST of the gel. Moreover, the shrinking of the 1-1 gel is both faster and greater in extent than for the equivalent non-AA modified gel. Further, the shrinking of the 1-1 gel is more rapid and greater in extent than for the equivalent non-AA modified gel. This is characteristic of this equilibrium within the gel is shown in Fig. 3.

Intuitively it might be assumed that increasing the BSP-acrylate precursor ratio in the polymer formulation to 3% (gel 5-3) reduces the relative shrinking extent to 20%. This suggests that the incorporation of AAA into these gels simplifies the actuator operation by removing the need for prior soaking in HCl. When placed in DI water and in darkness, a yellow colouration of the surrounding water due to absorption of incandescent radiation is observed. This is inherent to the shrinking mechanism. However, the results in Fig. 4 suggest that there is an optimum BSP content of 1% for these gels, and this value is also shown to shrink slightly even at temperatures several degrees below the actual LCST of the gel.

Reswelling of the gels can be observed after 1 hour storage in darkness. When the BSP content in the gel formulation will increase the rate and extent of conversion of MC to BSP, rather than the deprotonation of MC-H⁺. In the light, they were kept contracted form under white light irradiation, they, were kept contracted form under white light irradiation (Gel 0-0, Fig. 2 and 4) occurs. In fact, the temperature rose from the initial 18°C to 22°C during the 20 min period of measurement. Therefore, increasing the BSP content in the gel formulation will increase the rate and extent of conversion of MC to BSP, rather than the deprotonation of MC-H⁺. However, increasing the BSP content in the gel formulation will increase the rate and extent of conversion of MC to BSP, rather than the deprotonation of MC-H⁺. This is characteristic of the protonated MC form (MC-H⁺) rather than the deprotonated MC form (MC-H⁻). Therefore, increasing the BSP content in the gel formulation will increase the rate and extent of conversion of MC to BSP, rather than the deprotonation of MC-H⁺.
1. Testing and integration of light activated polymer valves

Linear photo-actuator =

Ionic Liquid =
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Monomeric Ionic Liquid =

Linear photo-actuator =

Crosslinker = (PPO 800)

Advantages

- Ever-present liquid phase
- Enhanced swelling/shrinking
- Improved mechanical properties
- Conductive Matrix

- Incorporation of other conductive materials (conductive polymers)

2. Development of nanostructured conducting polymers and nanocomposites (POLYMAT, DCU).
3. Development of biocompatible organic ionogels

- Collaboration with Prof. R. M. Owens and Prof. G. Malliaras

- Previously demonstrated the application of ILs as electrolytes for the development of OECTs for sensing glucose [1] and lactic acid [2].

- IL incorporation into a polymeric matrix (an ionogel) to achieve a solid-state electrolyte [2].

- Synthesis of biocompatible hydrated choline ionic liquids [3].

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