Claims

1. A hygroscopic hydrogel that switches between a hydrated state and a dehydrated state upon absorbing and desorbing water, respectively, the hydrogel comprising a non-stoichiometric oxide of a transition metal, X, wherein the hydrogel in its dehydrated state has a molecular structure with a transition metal to oxygen (X:O) ratio of 1:1.1-1:1.5, and wherein the transition metal is: zinc (Zn), copper (Cu), iron (Fe), silver (Ag), or a combination thereof.

2. The hydrogel according to claim 1, wherein the switch between the hydrated state and the dehydrated state causes a change in the optical, electrical and/or electrochemical properties of the hydrogel.

3. The hydrogel according to any preceding claim, wherein the hydrogel is porous.

4. The hydrogel according to any preceding claim, wherein the hydrogel is amorphous.

5. The hydrogel according to any preceding claim, wherein the hydrogel switches between the hydrated state and the dehydrated state without external energy supply.

6. The hydrogel according to any preceding claim, wherein the hydrogel in its dehydrated state has an average optical transparency of ≥ 90% in light having a wavelength of 390-700 nm.

7. The hydrogel according to any preceding claim, wherein the hydrogel in its hydrated state has an average incident infrared (IR) transmittance of 50-65%.

8. The hydrogel according to any of claims 1 to 6, wherein ionic conductivity of the hydrogel increases as the hydrogel switches from the dehydrated state to the hydrated state.

9. The hydrogel according to claim 8, wherein the hydrogel is comprised in an electrochemical cell as an electrolyte.

10. The hydrogel according to any of claims 1 to 6, wherein electrical resistivity of the hydrogel decreases as the hydrogel switches from the dehydrated state to the hydrated state.

11. The hydrogel according to claim 10, wherein the hydrogel is comprised in an electrical circuit as a conductive ink.

12. A method of forming the hydrogel according to any of the preceding claims, the method comprising:

- mixing a transition metal acetate salt and an amino-alcohol in an alcohol to form a precursor solution, wherein the transition metal acetate salt is: zinc acetate, copper acetate, iron acetate, silver acetate, or a combination thereof;
- adding deionised (DI) water to the precursor solution to form a mixture; and
- annealing the mixture at a pre-determined temperature for a pre-determined period of time to form the hydrogel.

13. The method according to claim 12, wherein the amino-alcohol is: ethanolamine, propanolamine, or a combination thereof.

14. The method according to claim 12 or 13, wherein the alcohol is: ethanol, methanol, isopropanol, 2-methoxyethanol, or a combination thereof.

15. The method according to any of claims 12 to 14, wherein the pre-determined period of time is 10-30 minutes.

16. The method according to any of claims 12 to 15, wherein the pre-determined temperature is 30-80°C.

17. The method according to any of claims 12 to 16, wherein the method further comprises coating the mixture on a substrate prior to the annealing.

18. The method according to any of claims 12 to 17, wherein the hydrogel formed is in a dehydrated state.