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 claim 1 or 2, wherein the transition metal is: zinc (Zn), copper (Cu), iron (Fe), silver (Ag), or a combination thereof.~~

~~4.~~3. The hydrogel according to any preceding claim, wherein the hydrogel is porous.

~~5.~~4. The hydrogel according to any preceding claim, wherein the hydrogel is amorphous.

~~6.~~5. The hydrogel according to any preceding claim, wherein the hydrogel switches between the hydrated state and the dehydrated state without external energy supply.

~~7.~~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.

~~8.~~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%.

~~9.~~8. The hydrogel according to any of claims 1 to ~~7~~6, wherein ionic conductivity of the hydrogel increases as the hydrogel switches from the dehydrated state to the hydrated state.

~~10.~~9. The hydrogel according to claim ~~9~~8, wherein the hydrogel is comprised in an electrochemical cell as an electrolyte.

~~11.~~10. The hydrogel according to any of claims 1 to ~~7~~6, wherein electrical resistivity of the hydrogel decreases as the hydrogel switches from the dehydrated state to the hydrated state.

~~12.~~11. The hydrogel according to claim ~~11~~10, wherein the hydrogel is comprised in an electrical circuit as a conductive ink.

~~13.~~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.

~~14. The method according to claim 13, wherein the transition metal acetate salt is: zinc acetate, copper acetate, iron acetate, silver acetate, or a combination thereof.~~

~~15.~~13. The method according to claim ~~13 or 14~~12, wherein the amino-alcohol is: ethanolamine, propanolamine, or a combination thereof.

~~16.~~14. The method according to ~~any of~~ claim~~s 13 to 15~~12 or 13, wherein the alcohol is: ethanol, methanol, isopropanol, 2-methoxyethanol, or a combination thereof.

~~17.~~15. The method according to any of claims ~~13~~12 to ~~16~~14, wherein the pre-determined period of time is 10-30 minutes.

~~18.~~16. The method according to any of claims ~~13~~12 to ~~17~~15, wherein the pre-determined temperature is 30-80°C.

~~19.~~17. The method according to any of claims ~~13~~12 to ~~18~~16, wherein the method further comprises coating the mixture on a substrate prior to the annealing.

~~20.~~18. The method according to any of claims ~~13~~12 to ~~19~~17, wherein the hydrogel formed is in a dehydrated state.