Disease diagnosis: Chemical species detection in body fluids



Among the several essential trace elements of biology, iron, copper and zinc are three most important and crucial ones for life since two-thirds of the metalloenzymes performing various functions in the human body comprise these elements in the form of their ions, viz., Fe^{2+/3+}, Cu1^{+/2+} and Zn²⁺. Perhaps cobalt can be placed next to it though there are only limited number of enzymes in human body based on this element. The presence of these ions in human tissue in their optimal concentrations is essential for healthy life. If these are present at inappropriate levels (i.e., either in low or high concentrations) in human tissue, it would result in deficiency or toxicity (Refer table). Therefore, maintaining optimal concentrations of these ions is an important health concern in human. Similarly, amino acids, such as, cysteine, histidine and selenocysteine and the anionic species such as phosphate and fluoride are equally important in maintaining the cellular functions. Identification of the imbalance in the concentration of such ions (and/or molecules) is a pre-requisite to alert a person to approach for appropriate treatment. One of the important challenges in this regard is to detect these ions under biological conditions and to quantify so as to provide diagnosis for the disease. To tackle this, the following were done:

- We have developed molecular systems based on carbohydrates and calixarenes to sense and detect such ions in organic solvents then in water then in buffer and then in biologically relevant fluids. This is one of the important challenges to tackle in this regard and we are successful in developing selective sensors to various ions and molecules.
- We have further developed analytical, spectral and microscopy techniques which would quantify these ions.
- In order to bring their technological utility, logic gates were developed which can be converted into their software apps by engineers.

Element/Ion/ Molecule	Recommended intake in mg/day (adult)	Syndrome due to inappropriate levels
Iron	10 - 20	Anaemia, siderosis, hemochomatosis
Copper	02 - 05	Anaemia, kinky hair, Wilson's, Parkinson's disease
Zinc	12 - 15	Dwarfism, hypogonadism, metal fume fever
Cobalt	0.2 - 0.4	Anaemia, coronary failure, polycythemia, loss of appetite
Phosphate	25 - 30 (in terms of P)	Kidney damage, osteoporosis, hyperthyroidism
Fluoride	2.5 - 3	Dental and skeletal fluorosis, urolithiasis, and osteoporosis
Cysteine	400 - 500	Cancer, Alzheimer's apathy, edema and cardiovascular
Histidine	500 - 700	Histidinemia, rheumatic arthritis
Selenocysteine	15 - 20	Cancers, cardiovascular diseases, neurodegenerative diseases

In order to develop methodology for rapid analysis of such ion detection, that too in large number of samples (like that needed in hospital), test strip based kits can be used. The detection requires shining UV light on the test strip and observing the colour change. This is possible today by integrating UV lamp and analysis software into a smart phone in order to provide even quantitative measure.

With our approaches and team efforts, we could develop several chemical molecular systems and showed that such receptors selectively sense the ions/ molecules discussed above. The studies were further extended to show that some of these systems can work in clinically relevant samplings simply by using test strips under smart phones. This can be checked by any digital-literate and can be extended to multitude of samples which needs to be analysed in health care centers.

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