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FLUORESCENCE PROPERTIES OF QUERCETIN- A REVIEW

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ABSTRACT

This paper focuses on the fluorescent properties of quercetin. Quercetin is an important flavonoid of dietary and pharmacological significance. There are certain factors that affect the fluorescent intensity. Some of them increase the fluorescence, while others causes quenching effect. The fluorescent property of quercetin makes it a versatile flavonoid of analytical and biological importance.

KEYWORDS

Quercetin and Excited state intramolecular proton transfer (ESIPT).

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INTRODUCTON

Quercetin (QCT) belongs to a class of plant metabolite called flavonoids. It is a major representative of flavonoid subclass of flavonols. Studies have proved that quercetin possesses various beneficial effect on human health. It posseses antioxidant, anticancer, anti-inflammatory, antiarthritic, antibacterial and anti hepatoprotective activities[1]. Quercetin is a key component of various cosmaceuticals, especially for anti-aging and nutraceuticals. Quercetin is one of the most abundant flavonoids widely distributed among citrus fruits, onions, nuts, green tea, apples and green leafy vegetables. It is available in market in

tablets, capsules, powders and emulsion formulations as well as nanoformulations either alone or along with other natural drugs[2].

PHYSICOCHEMICAL PROPETIES OF QUERCETIN

Quercetin is yellow coloured crystalline powder having a lipophilic character. It has melting point in the range of 310-317^{0}C and sublimes at its boiling point. It is practically insoluble in water and stable under ordinary condition, but sensitive to moisture. Quercetin is 3, 3', 4', 5, 7-pentahydroxyflavone and the structure is completely planar, composed of two benzene rings linked with a heterocyclic pyrone ring to form aromatic trimeric heterocycle (Figure No.1). Each molecule of quercetin contain five hydroxyl groups whose presence determines the compound's biological activity and possible number of derivatives[3].

FLUORESCENT PROPERTIES OF QUERCETIN

Flavonols, such as QCT, that contain -OH group at position 5 (C-5) have been considered to comprise a special class of non-fluorescent molecules though anomalous characteristic fluorescence properties of these molecules have been reported in various hydro-organic mixed solvents.

In certain biological and physicochemical studies QCT is employed as a fluorophore. The specific binding to a biomolecule or the localization in a given microenvironment induce partial formation of one or more species that absorb(s) at higher wavelength and/or fluoresce(s) with higher quantum yield than neutral QCT. Fluorescence excitation spectra are consistent with partial formation of one (or more) anionic form(s) of QCT[4].

QCT glycoside, which also contains -OH group at C-5, when excited to a 2nd excited state at the specific environments such as in hydro-organic mixed solvents or aerosol-OT (AOT) reverse micelle, a new significant fluorescence emission is found. If the molecules are excited to first excited state in organic solvents, QCT exhibit no fluorescence due to excited state intramolecular proton transfer (ESIPT) between the –OH and the carbonyl oxygen[5].

FACTORS AFFECTING FLUORESCENT PROPERTIES OF QUERCETIN

Solvent

In aqueous solution, since the intermolecular hydrogen bond between the polar groups of solute and H_2O will exceed the various intramolecular hydrogen bonds, the dihedral angle will be large, making it very difficult for ESICT (excited state intramolecular charge transfer) to occur. Because the radiation less pathway by way of the formation of a distorted excited state will become very active in water, no fluorescence emission is observed.

In hydro-organic mixed solvents like CH_3OH and CH_3CN, almost all of the QCT molecules have several intramolecular hydrogen bonds between the -OH group and carbonyl oxygen. In this case, since the ESICT should occur easily, QCT can exhibit fluorescence emission[6].

Another excited state phenomenon, ESIPT (excited state intramolecular proton transfer) can occur between the 5-OH and keto oxygen via an intramolecular hydrogen bond. The "nodal plane" model demonstrates that the S1 state is much more susceptible to ESIPT compared with the S2 state. ESIPT can occur quickly in QCT due to the plane molecular structure. Since the formation of the distorted excited state by this ESIPT could be the result of interactions between the emitting state and other nearby excited states, the S1 → So fluorescence emission of QCT have not been observed in the organic solvents.

When the QCT is excited to the S2 state, it will be very difficult to take place ESIPT, but on the other hand ESICT should occur easily. Because the FC (Franck-Condon) factors of QCT involved in the S2 → S1 internal conversion will be very small, QCT exhibit strong S2 → So fluorescence emission in the organic solvents[7].

Composition of hydro-organic solvent mixtures

Composition of the solvent influences the fluorescence intensity. QCT show a steady state fluorescence in aqueous-organic mixed solvents like CH3OH-H2O and CH3CN-H2O.As the amount of

water increased in the mixed solvents, the fluorescence intensity of QCT gradually decreased regardless of the excitation light wavelength. When the water composition became more than about 60% fluorescence emission disappeared entirely[6].

pH

Studies on QCT-Aluminium (III) complex revealed that fluorescence intensity is depend on the pH. The fluorescence of QCT is absent in neutral and alkaline solution. The influence of pH on the fluorescence intensity of QCT- Al (III) complex is studied in the range of 2.0-5.5 and it was found to exhibit a complex shape and the optimal pH value was found to be 3.30[5].

Protein-binding

The flavonoid QCT have the ability to bind with proteins such as hemoglobin and albumin. The fluorescence intensity of hemoglobin gradually decreased when the solution of QCT is added[8]. QCT binds to HbA with high affinity and strongly quenches its intrinsic (tryptophan) fluorescence by static quenching. Stern-Volmer study indicates that static along with quenching mechanisms are accountable for the quenching of protein fluorescence by QCT. The fluorescence quenching data are analyzed by the Stern–Volmer equation

$$\frac{F0}{F} = 1 + K_{SV}[Q]$$

Where *F*0 and *F* are the fluorescence intensities before and after the addition of the quencher, respectively. [*Q*] is the concentration of the quencher and *K*SV is the Stern–Volmer quenching constant. The quenching constant can be explained as the association constant or binding constant of the complexation reaction as static quenching arises from the formation of a dark complex between the fluorophore and the quencher.

There is another similar study of quenching of fluorescence of egg albumin (EA) in SPAN 40 by binding with QCT. The results of this fluorescence quenching experiment illustrate that there is a strong binding force between QCT and egg albumin and that the binding site formed would be one. Drug, is bound to EA and a drug–EA complex is formed, which resulted in the quenching of the fluorescence of the egg albumin[9].

The same thing also studied using human serum albumin (HSA). i.e. the quenching of intrinsic fluorescence of HSA in presence of different concentrations of QCT.

APPLICATIONS

Determination of germanium in drugs and whole meat oats

A spectrofluorometric method is described for the determination of germanium (IV) based on its complexation reaction with QCT. It is based on the instant formation of the fluorescent complex of QCT with Ge (IV) in presence of a non-ionic surfactant. This method for determination of germanium is sensitive, offers a shorter analysis time, a minimal consumption of organic solvent and a more extended linear working range[11].

Quantitative determination of proteins

The interactions of small molecules like QCT with biomolecules such as proteins and nucleic acid have aroused great interest among chemists and biologists. The study of supramolecular interaction between them is useful for understanding the structures and functions of biomolecules. The quantitative determination of proteins is very important in clinical tests and biological techniques because it is often used as a reference for the measurement of other components in biological systems[12].

Detection of copper ions in water

A natural QCT-based fluorescent sensor for highly sensitive and selective detection of copper ions has been studied. The QCT fluorescent sensor after binding to Cu^{2+} ions in pH 7.40 buffered solution showed a quenching of fluorescence emission intensity applied to the quantification of Cu^{2+} ions in water samples[13].

Study of intracellular metabolism of QCT

QCT exhibit a specific fluorescence when bind with intracellular proteins. QCT, at physiologically relevant concentrations was found to exhibit a specific fluorescence (488 nm_{ex}/500−540 nm_{em}) upon internalization. This property provides a valuable, selective alternative technique for QCT

tracing in cellular system, permitting the quantitative evaluation of its transit at pharmacologically relevant concentrations and validation of number of already described molecular functions[14].

Estimation of QCT

Florescence property of QCT has been used for its estimation in formulations and plants. The estimation QCT in formulation is based on the formation of aluminum complex in acidic pH with enhanced fluorescence and stability[5]. Fluorimetry has also been used for the simultaneous estimation of QCT and glycyrrhizin in plants[15].

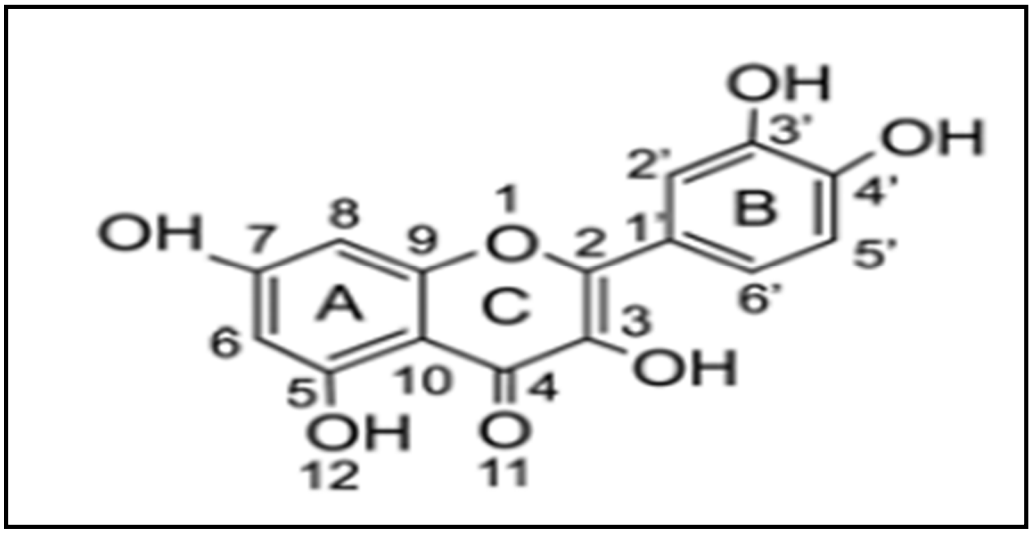
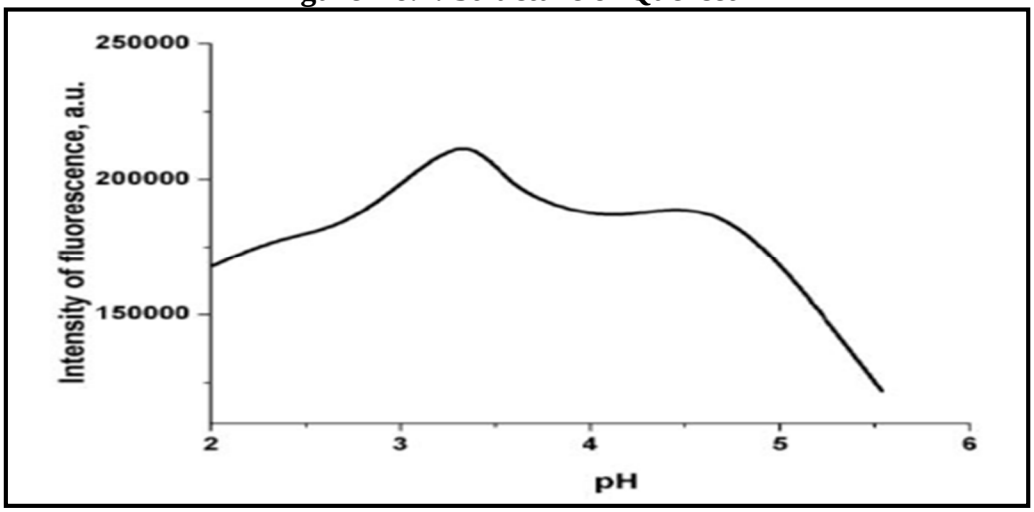
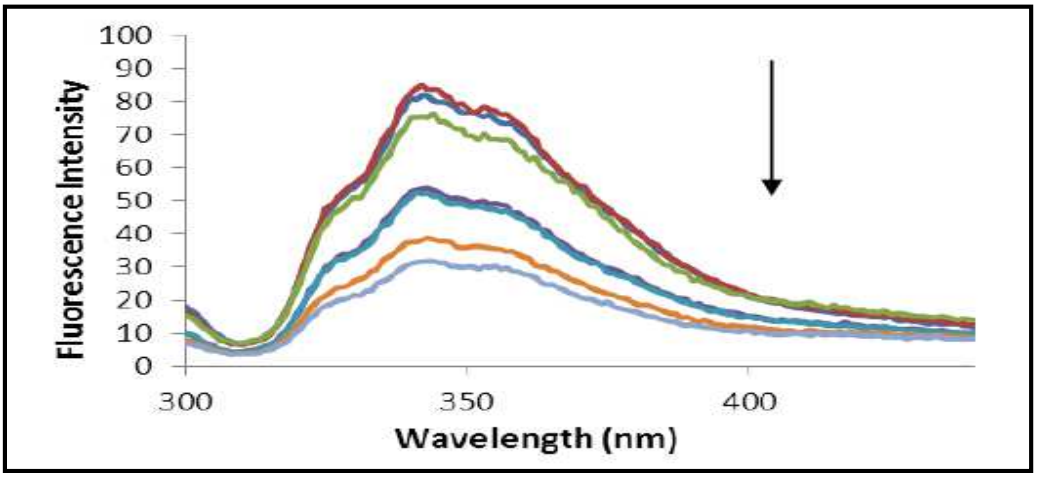


Figure No.1: Structure of Quercetin



Effect of pH on the intensity of fluorescence of Aluminum (III)–QCT complex



Fluorescence Emission Spectra of HbA with QCT

CONCLUSION

The review has revealed that quercetin has a complex fluorescence property and it is not fully exploited for its analytical applications. This review article may be useful to the researcher to carry out the Quercetin (QCT) in the field of pharmaceutical sciences.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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