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A Review on the Photophysical Properties of Imidazo[1,2-A]Pyridines

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ABSTRACT

A novel class of compounds, imidazo[1,2-a]pyridine derivatives showing electronic absorption and fluorescence spectral properties due to π-expanded conjugation . These properties making them extremely useful for photovoltaic as well as biomedical applications. This review is entirely devoted to the applications of imidazo[1,2-a]pyridine as fluorescent reporters in biological imaging.

Keywords: lockdown; online pedagogy; students; teachers; perplexed; learning

1. Introduction

Among heteroaromatics, imidazopyridine where imidazole moiety is fused with the pyridine ring play vital role in various bioactive molecules as well as in natural products1.1 Out of different imidazopyridine derivatives, the imidazo[1,2-a]pyridine moiety is the most important area of natural products and pharmaceuticals. Further more, these derivatives also show a wide range of biological activities such as antifungal2, antiinflammatory3, antitumor4, antiviral5, antibacterial6, antiprotozoal7, antipyretic8, analgesic9, antiapoptotic10, hypnoselective11, and anxioselective activities. Different drugs which contain imidazo[1,2-a]pyridine moiety are zolpidem, alpidem, olprinone, zolimidine , necopidem and saripidem available in the market. Rifaximin (antibiotic drug) also contains this fused heterocyclic moiety.

Phtotophysical properties.

Accordingly, out of diversified applications of imidazo[1,2-a]pyridine, the photophysical properties are well explored in the literature. Imidazo [1,2-a]pyridines and pyrimidines are also attractive due to their physicochemical properties such as the fluorescent activity. Effect of substituents on fluorescent properties of Imidazo [1,2-a]pyridines have been reported. The fluorescence emissions with excellent quantum yield is due to the π-conjugated bicyclic structure.

The experimental evidence demonstrated that the substitution with phenyl or naphthyl groups in position C2 increased their fluorescence yield[12].Electron-donating substituents also improved the luminescence performance whereas electron-withdrawing substituents led to a less intense emissions.

Fluorescence emission of imidazo[1,2-a]pyridine derivatives.

The UV-Vis absorbance spectra of the different molecules were obtained in different solvents. For instance, the spectra of the product 7e are presented in Figure 1, where narrow absorption bands were detected with maximal absorbance at 250, 253, 253, and 254 nm for MeOH, ACN, THF, and DCM, respectively. In all cases, a secondary band was observed in the range from 280 to 360 nm. Similar patterns were observed with the other synthesized molecules (Figures 47 and 48 in Data S1). The photoluminescent behavior of the imidazo [1,2-a]pyridines were analyzed under 365 nm UVexcitation (Figure 2). As observed in the inset photographs, all the synthesized derivatives presented strong emission at the blue and violet regions of the electromagnetic spectrum upon dispersion in varied solvents. The wavelengths of maximal emission were registered at 395, 401, 428, 394, 398, and 400 nm for the compounds 7a, 7d, 7e, 7v, 7f, and 7g, respectively, while the most intense emission was presented by the methoxy-substituted derivative (7f). The different analyzed substitutions on the central imidazo[1,2-a]pyridine nuclei caused no deterioration of the fluorescent property, while important shifts

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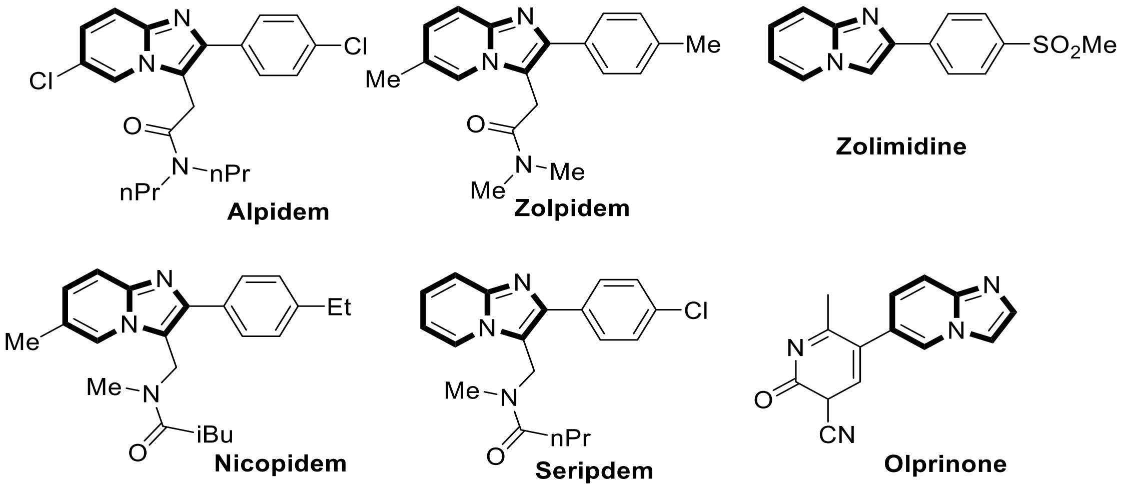

Figure 1. Imidazo [1,2-a] pyridine-based drugs.

were observed in the wavelength of maximal emissions, including regions from 394 until 428 nm. This strong emission was promoted by the extension of the electronic delocalization due to the presence of functionalized phenacyl substituents enclosed to the imidazo[1,2-a]pyridine nuclei[13].

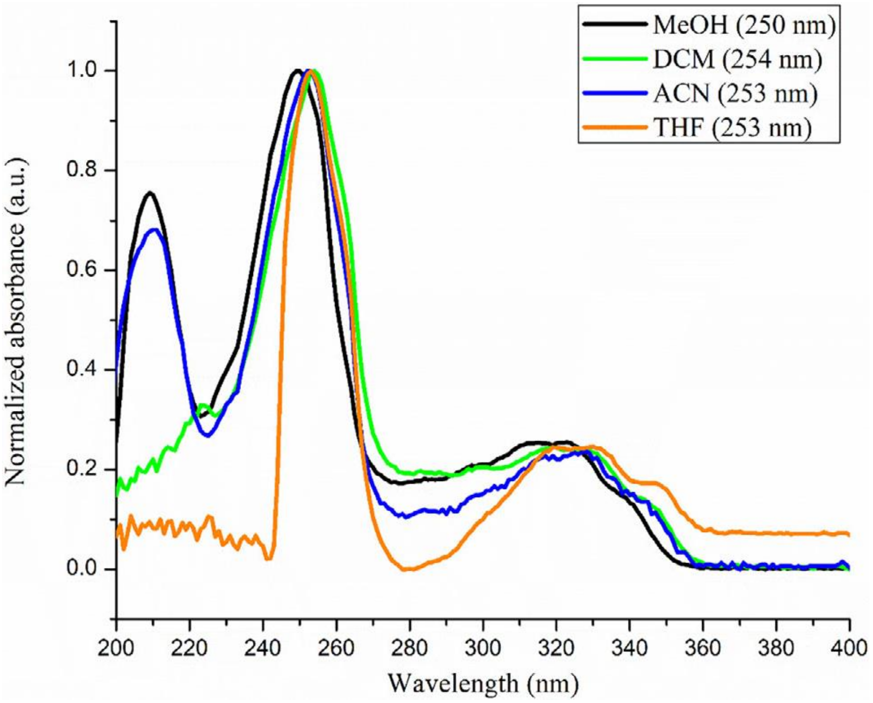

Fig 1.1 UV-Vis absorbance spectra of 7e in different solvents**.(Ref.13)**

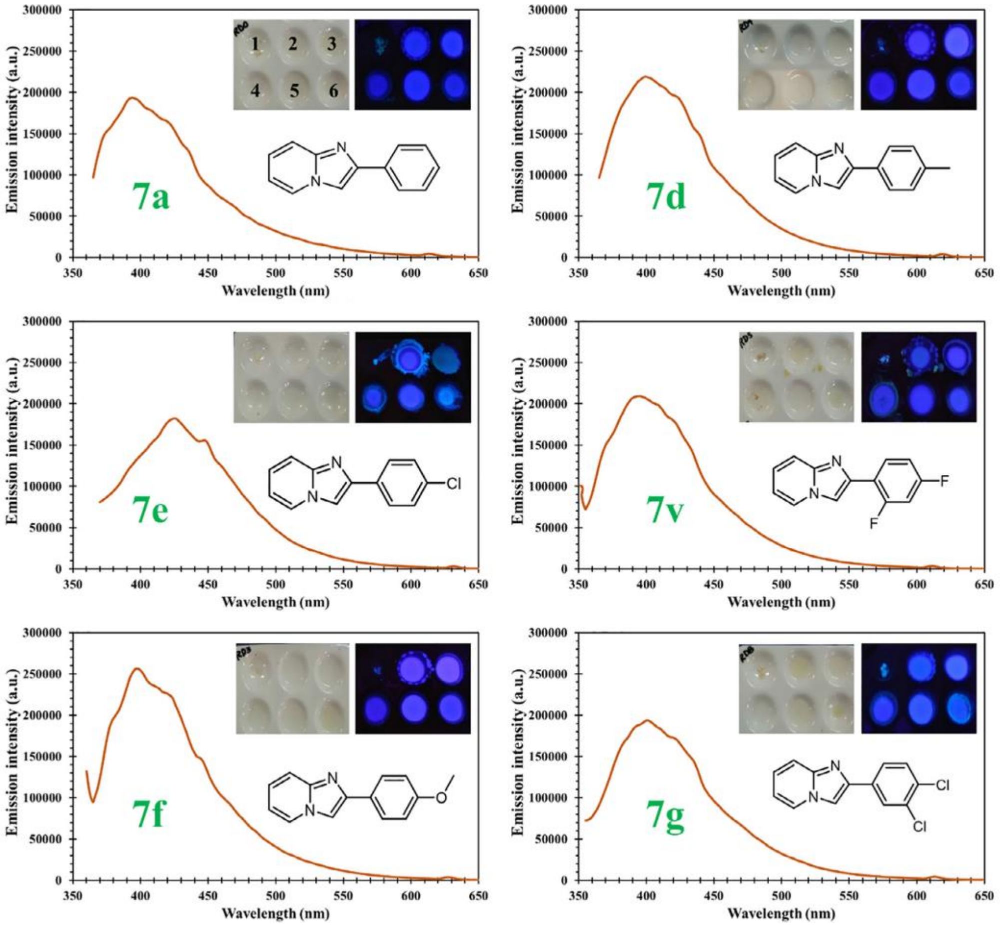

Fig 2: Fluorescence emission spectra of different imidazo[1,2-a]pyridine derivatives. The inset shows photographs of these molecules in different solvents under visible and 365 nm UV irradiation. (1) Dry compound, (2) MeOH, (3) THF, (4) Hexane, (5) ACN, and (6) DCM (**Ref.13**)

Fluorescence of imidazo[1,2-a]pyridines derivatives bearing an ortho-hydroxyphenyl.

These kinds of derivatives form conformations with orientations of the phenolic hydroxyl-group toward a nitrogen of the imidazole moiety, stabilized by a hydrogen bond. When such a molecule is promoted by the irradiation of light into its excited state, the imidazole nitrogens can act as acceptors of proton transfer reactions, changing the excited-state geometry and, consequently, the electronical properties, and forming a zwitter ionic molecule with a large charge transfer character. Such ESIPT reactions have been extensively studied by physical chemists, and they typically lead to very large Stokes shifts, which is a beneficial property for various applications. In the following years, these types of reactions were studied on a manifold of different imidazopyridines by various authors, who explained different effects of substitutions, metal ions, and solvents. It is noteworthy that this ESIPT can also be applied to crystalline imidazopyridines. In a publication by Mutai et al. The authors were able to show that an imidazopyridine crystallized as two different polymorphs can exhibit completely different solid-state fluorescent properties, both in emission wavelength and fluorescence quantum yield, depending on their ESIPT (Fig. 74).

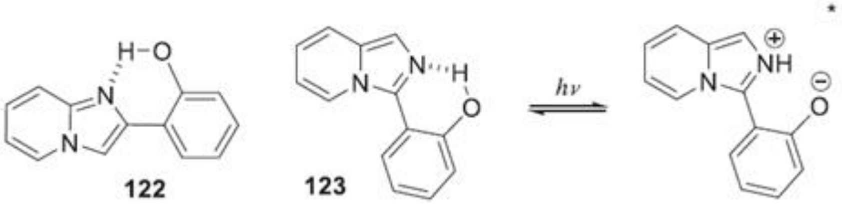

Fig. 3 Imidazopyridines with the possibility of an excited-state intramolecular proton transfer and the ESIPT reaction of these molecules.

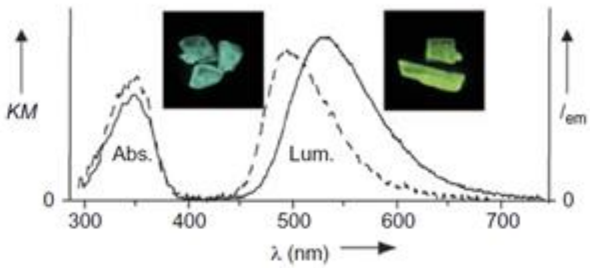

Fig. 4 The influence of the polymorphism of a crystalline imidazopyridine on its fluorescence emission. *Reproduced from T. Mutai, H. Tomoda, T. Ohkawa, Y. Yabe, K. Araki, Angew. Chem., Int. Ed., **47** (2008), 9522 with permission from WILEY-VCH.*

Fluorescence properties of phenanthro[9',10':4,5]imidazo[1,2-a]pyridine.

The photo physical properties of these molecules were thoroughly investigated. UV/Vis and fluorescence spectra of some selected compounds were recorded in CH2Cl2 (Figure 6). It was observed that the presence of electron donating group in C-ring enhances the fluorescence intensity (especially in para position, 5d) due to extended conjugation. Emission maxima of all the compounds appeared in the blue light region. Fluorescence quantum efficiencies of these compounds were calculated to be in the range of 0.22-0.61 using phenanthrene (ΦF= 0.125) as a standard (Table 3). A comparison chart of quantum efficiencies with some previously reported Imidazo[1,2-a]pyridine derivatives were tabulated (Table 3). The synthesized compounds also show a very interesting solid state fluorescence (white emitting, Figure 6c) when irradiated at 365 nm (Figure 6). Compound 5e and 5k showed best solid state fluorescence activity among all. These types of compounds with such properties have high potential to be used in the emerging field of optoelectronics such as OLEDs (Organic Light Emitting Diodes).

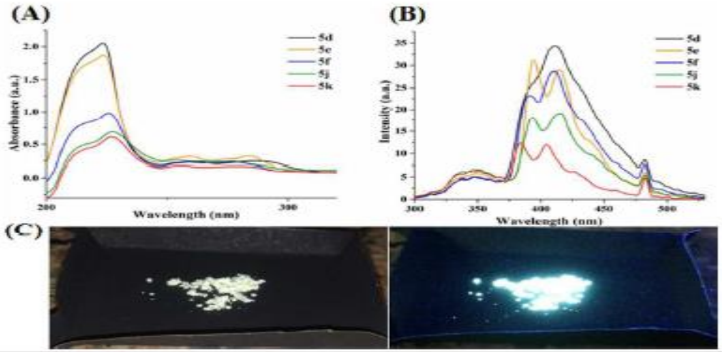

Figure 6: (A) Absorbance & **(B)** Emission spectra of some selected compounds (5 μM in CH_2Cl_2, λ_{ex}= 230 nm) along with **(C)** Normal light & solid state fluorescence of compound **5e** (hand held UV lamp at 365 nm)

2. Conclusion

A series of π-expanded imidazo[1,2-a]pyridine derivatives showing electronic absorption and fluorescence spectral properties designed for organic solar cell applications. As a result, imidazo[1,2-a]pyridine with luminescent properties are of great interest for fields such as chemical sensing, solid-state light emitters, photocatalysis, and optoelectronics.

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