

Design and Synthesis of *Bis(2-hydroxy-3-allyl)m-phenylenebenzamide* as a Neutral Host and its Complexation with Electrophilic Metal Cations

Mahshid Nikpour Nezhati, Homayon Ahmad Panahi and Masoumeh Ahmadian

Department of Chemistry, Islamic Azad University, Central Tehran Branch, Tehran, Iran

Abstract: Salicylic acid Esterification with ethanol and its subsequent reaction with allyl bromide, thionyl chloride and *m*-phenylenediamine in individual steps, resulted in to the production of *bis(2-hydroxy-3-allyl)-m-phenylenebenzamide*. The new synthesized molecule acted as a host-guest system due to the coordinating sites which can adsorb and chelate metal ions potentially. In each step the product was characterized and confirmed by spectroscopic methods (FT-IR, ¹H-NMR, ¹³C-NMR and SEM). The ability of *bis(2-hydroxy-3-allyl)-m-phenylenebenzamide* for chelating heavy metal ions, has been indicated by TLC method. The silica gel TLC plates were impregnated with 1-5 % solution of Cu (II), Ag (I), Hg (II), Pb (II), Ni (II) and boric acid. Methanol was chosen as mobile phase among surveyed solvent systems. The *R_f* value proved to be lower if *bis(2-hydroxy-3-allyl)-m-phenylenebenzamide* was developed with mentioned mobile phase on TLC plates with more percent of boric acid and metal ions.

Key words: *Bis(2-hydroxy-3-allyl)-m-phenylenebenzamide* • Complexation • Neutral host

INTRODUCTION

Various metals were recognized as serious environmental problems worldwide due to important effect on human health and environment. Omitting metal ions of wastewater is necessary in order to control the environmental pollution. Although traditional methods were used for omitting during many years, but they are not useful due to efficiency and operational cost. Molecules containing coordination site for a cation, have been recognized useful as SPE media for the determining various trace elements [1]. In addition such organometallic compounds have been used widely as catalyst in different organic reactions. A synthetic host molecule should show selectivity in complexation of guest molecules (recognition) and the synthesis of pre organized host molecules presents an interesting challenge [2]. The host molecule could possess multiple and convergent binding sites that are well located in a well-defined structure. There are few examples for using convergent hydroxyl group as the primary binding sites [3-9]. Non-ionized hydroxyl group of phenols are found in active sites of enzymes (e.g. carboxy peptidase) and play important role in the way that ionophores wrap around the metal ions [10].

Complex of (poly functional) organic guest species with biological and industrial importance, such as urea, guanidine, methanol, have been reported [11, 12]. Furthermore cyclic polyethers are considerable due to their ability to build complexes with metal ions [13]. The Schiff base condensation products of salicylaldehyde and aromatic or aliphatic di- amines, the so-called salen type ligands (salen= N,N-ethylene bis(salicylidene aminato)) well known to form very stable complexes with transition-metal cations [14,15].

We decided to incorporate such moiety in a new type of ligand. We report here synthesis of *bis(2-hydroxy-3-allyl)-m-phenylenebenzamid* (Figure 1) with coordinating sites by ability to adsorb metal ions potentially (such as Cu, Ag, Ni, Pb and Hg) and boric acid after deprotonation of phenol groups.

Experimental

Instruments and Chemicals: The ¹H-NMR and ¹³C-NMR spectra were recorded with Bruker 300 Arance spectrometers in CDCl₃. IR spectra were obtained with a FT-IR (JASCO FT/IR-410) spectrophotometer.

All chemicals were reagent grade and were used without further purification.

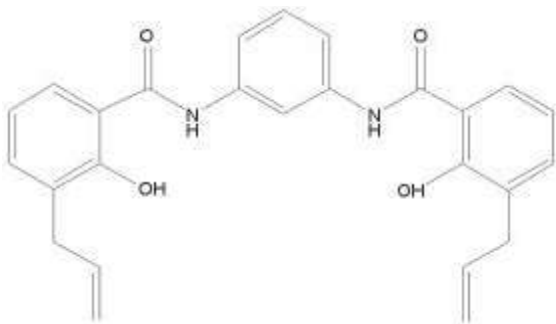


Fig. 1: The structure of *bis* (2-hydroxy-3-allyl)-*m*-phenylenbenzamid (5)

List of Materials: K_2CO_3 , *N,N*-dimethylacetamide were supplied from Scharlau company. Thionyl chloride was obtained by Accrose company and 3-bromo-1-propene, ethanol, salicylic acid, boric acid, sulfuric acid, 1,3-phenylen diamine, $NaHCO_3$, $MgSO_4$, Na_2CO_3 , HCl, methanol, CH_2Cl_2 , petroleum ether-benzene, charcoal, $AgNO_3$, $Pb(CH_3COO)_2$, $HgCl_2$, $CuCl_2 \cdot 2H_2O$ and $NiCl_2 \cdot 6H_2O$ were purchased from Merck.

TLC Method: All silica gel plates were pre-developed prior to use, with chloroform methanol 1:1 (v/v) and air-dried over the night. The plates then were impregnated with boric acid and metal ions by dipping them upside-down into a solution of 1,2,3,4 and 5% boric acid in absolute ethanol-water 1:1 (v/v) and metal ions (Pb (II), Ag (I), Cu (II), Ni (II) and Hg (II)). After air drying for 15 min, plates were activated at 100 °C for 60 min. Samples of *bis*(2-hydroxy-3-allyl)-*m*-phenylenbenzamide in dichloromethane (1%, w/v) were spotted on the adsorbent, then developed in methanol, equilibrated previously for 60 min. After developing by mobile phase in a distance of 80 mm from origin, the plate was dried and position of the analysts visualized by UV detection and R_f values were verified separately for each compound.

General Procedures in Synthesis: 2-(allyloxy) benzoic acid (3) was obtained by heating 2-allyloxy-ethyl benzoate (2) and its saponification as reported [18]. 2-allyloxy-ethyl benzoate (2) was prepared from ethyl salicylate (1). We carried out suitable reaction by using the standard method for allylation of phenol and esterification of salicylic acid [19].

Synthesis of 2-(Allyloxy) Benzoyl Chloride (4): A mixture of 2-(allyloxy) benzoic acid (0.05 mole, 0.15 gr.) and thionyl chloride (0.15 mole, 11.16 ml.) was gently refluxed for 2h. The excess thionyl chloride was distilled off at reduced pressure and acid chloride was extracted with

petroleum ether-benzene, dried ($MgSO_4$) and evaporated. Based on the Fries rearrangement, the main product is a balance mixture of 2-(allyloxy) benzoyl chloride and (3-allyl-2-hydroxy) benzoyl chlorid. b.p.: 80-85°C; Yield: 96%; 1H -NMR (300 MHz, $CDCl_3$, δ , ppm): 8.03-8.06 (d, $J=7$ Hz, 1H), 7.50-7.56 (t.d, $J_1=1.8$, $J_2=7$ Hz, 1H), 6.95-7.04 (t.d, $J_1=6$ Hz, $J_2=6$ Hz, 2H), 5.96-6.08 (m, 1H), 5.49-5.55 (d.d, $J_1=15$ Hz, $J_2=1.5$ Hz, 1H), 5.27-5.31 (d.d, $J_1=12$ Hz, $J_2=1.5$ Hz, 1H), 4.61-4.62 (d, $J=3$ Hz, 2H (Allylic)); ^{13}C -NMR (300 MHz, $CDCl_3$, δ , ppm): 165.39 (C=O), 120.43-158.46 (C_{1-C_5}), 117.69 (C=C), 70.67 (CH_2); IR (KBr, thin film, cm^{-1}): 3081-3400 (OH), 3031-3081 (Aromatic CH, Stretching), 2977 (CH_2), 1778 (C=O), 1481, 1596 (Aromatic C=C), 1450 (Allylic C=C), 1395 (CH_2 , bending), 963, 995 (Allylic C-H), 550-730 (C-Cl, bending) cm^{-1} .

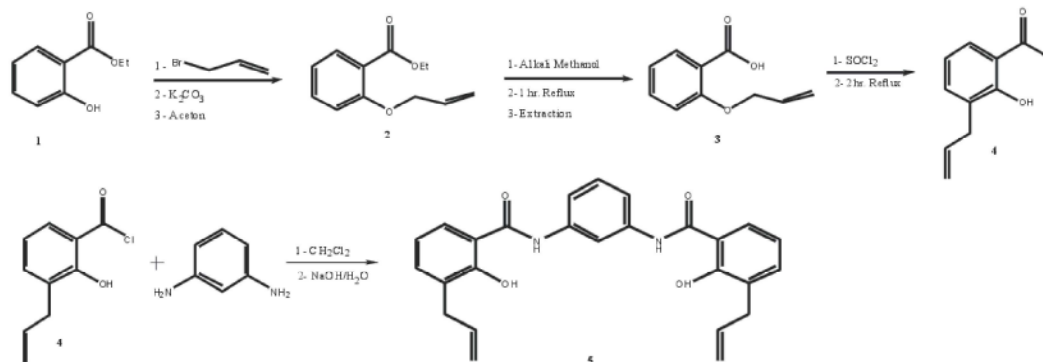
Synthesis of Bis(2-hydroxy-3-allyl)-*m*-phenylenbenzamid (5): *M*-phenylen diamine (0.02 mole, 2.17 gr.) was dissolved in 40 ml. cold solution of 2-(allyloxy) benzoyl chloride (0.04 mole, 7.49 gr.) in CH_2Cl_2 (8 ml.) by stirring. The reaction mixture was stirred for 20 min, giving *bis*(2-hydroxy-3-allyl)-*m*-phenylen benzamide (5) as brown powder. After filtering (buckner funnel), the precipitate was washed by HCl 5%, $NaHCO_3$ 5% and water and dried in the room temperature.

Then the filtrate was dissolved in dimethylacetamide (7 ml.) and was treated with charcoal. The mixture was filtrated and the solution was crystallized by careful addition of water. The residue was filtered (buckner funnel) and was dried in the room temperature.

Brown powder; m.p.: 97-99 °C; Yield: 65%; 1H -NMR (300 MHz, $CDCl_3$, δ , ppm): 10.05 (s, OH), 8.30-8.33 (d.d, $J_1=6$ Hz, $J_2=6$ Hz, 2H), 8.16-8.18 (d.d, $J_1=2$ Hz, $J_2=2$ Hz, 1H), 7.40-7.52 (2H (NH), 2H (H_b)), 7.33-7.36 (d.d, $J_1=9$ Hz, $J_2=6$ Hz, 1H), 7.13-7.18 (t, $J_1=8$ Hz, $J_2=7.8$ Hz, 2H), 7.03-7.06 (d, $J_1=7.8$ Hz, $J_2=1.8$ Hz, 2H), 6.19-6.32 (m, 2H), 5.52-5.61 (d.d.d, $J_1=17$ Hz, $J_2=10$ Hz, $J_3=1.2$ Hz, 4H), 4.77-4.79 (d, $J=6$ Hz, 4H(CH_2)); ^{13}C -NMR (300 MHz, $CDCl_3$, δ , ppm): 163.14 (C=O), 111.7-156.3 (C_{1-C_4} , C_6-C_{14}), 70.29 (C_5); IR (KBr, thin film, cm^{-1}): 3400-3500 (OH), 3374 (N-H), 3000-3200 (Aromatic C-H), 2325-2364, 2846-2912 (Aliphatic C-H, Stretching), 1658(C=O), 1600(N-H, Bending), 1538, 1600 (Aromatic C=C), 1488 (C-N, Stretching) cm^{-1} .

RESULT AND DISCUSSION

Now we report our primary results. Condensation reaction of 2-(allyloxy)benzoyl chloride and *m*-phenylenediamine produced *bis*(2-hydroxy-3-allyl)-*m*-phenylenebenzamid (5) with a total size of 34 atoms. Upon reaction of (5) with some metal ions, the phenolic OH



Scheme 1: Reaction pathway for synthesis of bis(2-hydroxy-3-allyl)-m-phenylenbenzamid (5)

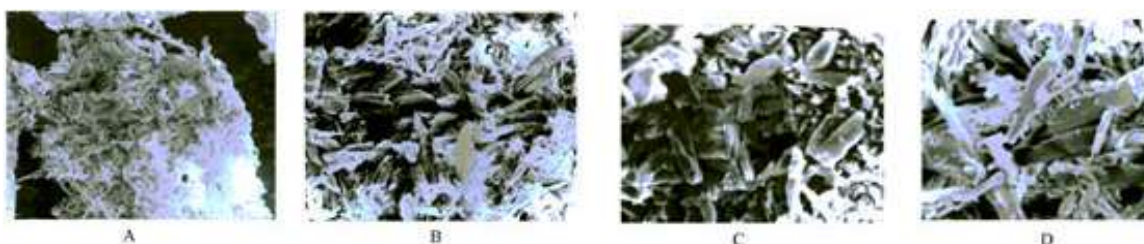


Fig. 2: SEM pictures of bis (2-hydroxy-3-allyl)-m-phenylenbenzamid (5)

Table 1: Effect of boric acid contents of TLC plates on R_f of bis (2-hydroxy-3-allyl)-m-phenylenbenzamide (5)

Percentage of compound in TLC plates	0%	1%	2%	3%	4%	5%
Cu (II)	0.85	0.77	0.72	0.70	0.69	0.68
Ag (I)	0.85	0.82	0.76	0.71	0.70	0.69
Ni (II)	0.85	0.80	0.78	0.77	0.71	0.70
Hg (II)	0.84	0.62	0.61	0.59	-	-
Pb (II)	0.85	0.77	0.73	0.69	0.63	0.60
Boric acid	0.85	0.81	0.78	0.74	0.70	0.69

groups were deprotonated and neutral complexes were formed. The part of this molecule corresponding to ligand will be referred to as the Schiff base moiety. 2-(Allyloxy)ethylbenzoate (2), was converted to 2-(allyloxy)benzoic acid (3) in alkaline methanol. Then it was refluxed with thionyl chloride in mild condition. After completing reaction, 2-(allyloxy)benzoyl chloride (4) was separated through liquid phase extraction. The key step of synthesis was coupling via reaction of (4) with *m*-phenylenediamine in the room temperature. The final product extracted with water as fine brown powder (schema 1).

Spectroscopic data showed that reaction occurred in amine sites. The product was characterized and confirm by spectroscopic methods in each step (IR, ¹H-NMR, ¹³C-NMR and SEM, Figure 2).

TLC method was used for indicating interaction between (5) with boric acid and metal ions. The basis of impregnation in silica-gel plate were developed by

Mezzetti *et al.* [16], when they observed that adding of boric acid to a solvent system, led to the preferential movement of certain sugar over the others. This led to the trying of various impregnates [17]. Among different solvent systems studied for an effective mobility of bis(2-hydroxy-3-allyl)-*m*-phenylenbenzamide (5) in impregnated silica gel plates, methanol was found to be more effective in all impregnated silica gel plates with boric acid and metal ions (unpublished data). Table 1 shows the effect of boric acid contents of TLC plates on R_f of bis(2-hydroxy-3-allyl)-*m*-phenylen benzamide (5).

Compounds containing hydroxyl group can react with boronate. The interaction that may occur is the formation of a cyclic ester complex, as illustrated in Fig. 1. These complexes can form with 1, 2- or 1, 3-diol, 1, 2- 1, 3 keto-ol and α -hydroxy acids compounds when the hydroxyl groups are oriented in the proper geometry like bis(2-hydroxy-3-allyl)-*m*-phenylenbenzamide (5).

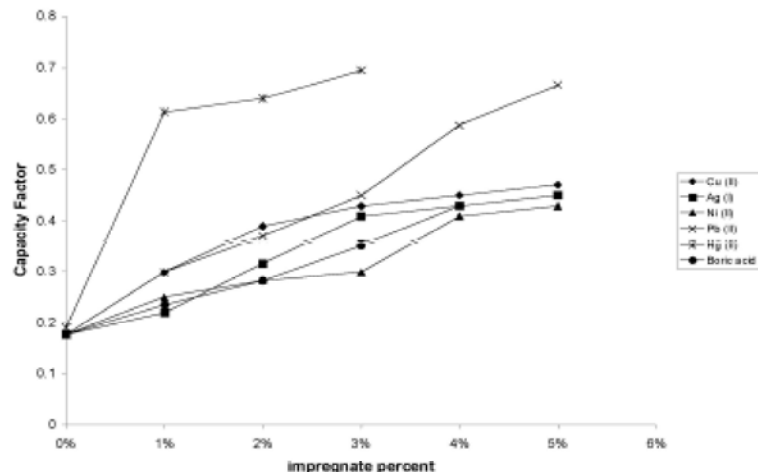


Fig. 3: Effect of boric acid contents of TLC plates on capacity factor (k')

In the case of non-impregnated plates the R_f of the *bis*(2-hydroxy-3-allyl)*m*-phenylenbenzamide was high. From Table 1 it is clear that (5) has lower mobility in impregnated plates. The R_f was decreased with increasing content of boronate in TLC plates. This trend of chromatographic behavior of (5) can be explained on its complex formation with boric acid. The same results were observed in impregnated plates with metal ions (Table 1). This Table showed that the *bis*(2-hydroxy-3-allyl)*m*-phenylenbenzamide (5) has lower mobility in metal ions impregnated plates. This indicates that there is an interaction between metal ions and (5). *bis*(2-hydroxy-3-allyl)*m*-phenylenbenzamide can act as a chelating agent for metal ions, so the mobility of this compound decreased in impregnated plates with metal ions. In other word, because of interaction between (5) and metal ions, the metal ions on the TLC plates play a retarding agent for mobility of *bis*(2-hydroxy-3-allyl)*m*-phenylenbenzamide on the impregnated plates.

The effect of boric acid contents of TLC plates on separation was also investigated. Capacity factor (k') for each experimental point has been indicated in Figure 3. This Figure shows that capacity factor goes up with increasing amount of boric acid and metal ions the plates.

CONCLUSION

The synthesis of (5) was carried out as shown in schema 1. The reaction of ethylsalicylate (1) and allyl bromide produced 2-(allyloxy)ethylbenzoate (2), which was converted to 2-(allyloxy) benzoic acid (3) in alkaline methanol. 2-(allyloxy) benzoyl chloride (4) was separated via chlorination of (3) with thionyl chloride. In final step,

the reaction of (4) with *m*-phenylenediamine in the room temperature produced (5) as fine brown powder. For recognizing structure of all synthesized compounds suitable spectroscopic methods (IR, $^1\text{H-NMR}$, $^{13}\text{C-NMR}$ and SEM) were used. It has been found that new compound (5) can coordinate potentially (Ag, Hg, Pb, Ni and Cu cations) as well as boric acid. TLC method was used for determining these metal ions adsorption by (5). Good results were related for Ag, Ni, Pb and Hg. The R_f value was proved to be lower if *bis*(2-hydroxy-3-allyl)*m*-phenylenbenzamide was developed by methanol on TLC plates containing more percent of boric acid and metal ions.

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