12th International Electronic Conference on Synthetic Organic Chemistry (ECSOC-12) 1-30 November 2008
http://www.usc.es/congresos/ecsoc/12/ECSOC12.htm & http://www.mdpi.org/ecsoc-12

[E0002]

Synthesis in water under Focussed Microwave Irradiation: a Rapid and Convenient Synthesis of Polyaminopolymethylenephosphonic acids

Didier Villemin[1]*, Bernard Moreau[1], M'hamed Kaid[2], Mohamed A. Didi[2], Paul-Alain Jaffrès[1,3]

[1]ENSICAEN, Université de Caen- Basse Normandie, LCMT, UMR CNRS 6507, F-14050, Caen, France.
E-mail: didier.villemin@ensicaen.fr

[2]Laboratoire des Technologies de Séparation et de Purification, Département de chimie, Université de Tlemcen, Algérie
[3]Present adresse: CEMCA, UMR CNRS 6521, Université de Bretagne Occidentale, F-29238, Brest, France

Abstract: *Polyamines in presence of phosphorus acid and formaldehyde in water under focussed microwave irradiation conduct to the rapid synthesis of polyaminomethylenephosphonic acids.*

Keywords: *Polyphosphonic acid, microwave irradiation, water solvent.*

INTRODUCTION

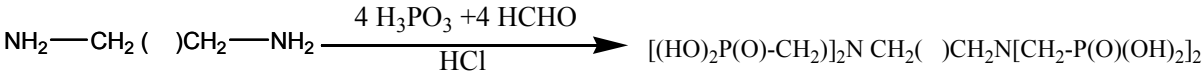
Aminophosphonic acids constitute an important class of biologically active compounds, and their synthesis has been a focus of considerable attention in synthetic organic chemistry as well as in medicinal chemistry [1]. These acids are considered to be structural analogues of the corresponding amino acids: thus acting as competitive inhibitors they can act as false substrates during the course of amino acid metabolism. Aminophosphonic acids are also very good ligands for the coordination of metal ions so they can be used for the extraction of metals [2] such as iron, copper, nickel and uranium in hydrometallurgy. These acids form also complexes [3] on the surface of metal such as iron and are consequently are very good as anti-corrosion agents [4]. These acids are also precursor of organic materials [5] or hybrid materials of metal organic frameworks (MOF) [6].The phosphonic acids can be also useful for the modification of inorganic surfaces or for grafting organic compounds on inorganic surfaces [7]. They can be used for making supported catalysts [8] or modified inorganic nanoparticles [9].

RESULT AND DISCUSSION

The aminophosphonic acids are generally obtained by hydrolysis of esters via Kabachnik-Fields reaction [10]. This reaction can be activated by microwave irradiation [11]; nevertheless there are often secondary reactions during the hydrolysis. The synthesis of Irani-Moedritzer [12] is less general than the Kabachnik-Fields reaction, but it has the advantage of obtaining the aminophosphonic acid without a step of hydrolysis. The Irani-Moedritzer reaction times are in general long, so the use of microwave for assisting the reaction is of interest. We describe this reaction in aqueous medium under microwave irradiation with an aqueous solution of formaldehyde in acidic aqueous medium without organic solvent. Water is an inexpensive, non flammable, non toxic solvent and has the advantage of warming up quickly under microwave irradiations. Carrying out reactions using microwave heating, as opposed to conventional heating, has the major advantage of shorter reaction times because of the rapid heating [13].

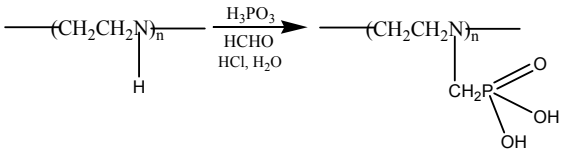
The Irani-Modzdrizer reaction can be compared to a Mannich reaction and takes place by the addition of the phosphorous acid on iminium salt formed by reaction of formaldehyde with the amine in acidic medium.

General procedures for the synthesis of various polyaminopolymethylene phosphonic acids consist to refluxing polyaminoalkyls with phosphorus acid and formaldehyde in HCl media (Schemes 1).



Scheme 1

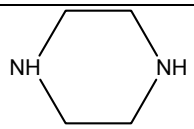
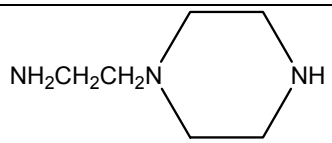
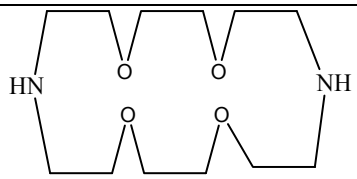
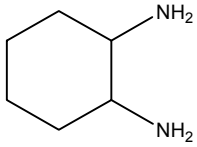
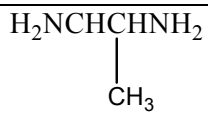
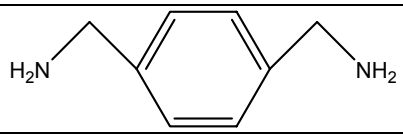
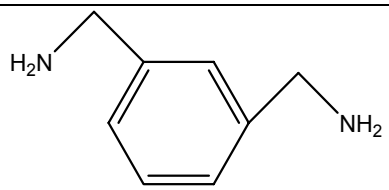
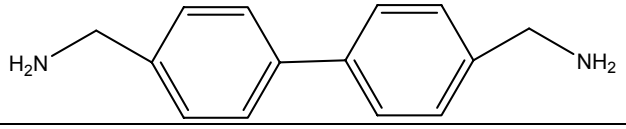
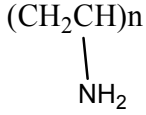
With the polyethylenimine, we have obtained a polymeric aminophosphonic acid (entry 18) useful as resin for extraction of metal ions (Scheme 2).



Scheme 2

The reactions were carried out in tubular reactor fitted with an effective cooling which permits to reflux solution without the formaldehyde escaping from the reaction media. This reactor was irradiated in a resonance mono-mode cavity Synthewave 402. Although the reaction also take place under multimode irradiation of a commercial furnace, the yields obtained are worse(conditions and yield see Table 1).

Table 1

entry	Amine	Yield (%)	W/min microwave
1	$NH_2CH_2NH_2$	60	240/10
2	$NH_2CH_2CH_2NH_2$	63	240/10
3	$NH_2(CH_2)_3NH_2$	64	240/12
4	$NH_2(CH_2)_4NH_2$	68	240/15
5	$NH_2(CH_2)_6NH_2$	91	240/20
6	$NH_2(CH_2)_8NH_2$	64	240/15
7	$NH_2(CH_2)_{12}NH_2$	93	240/30
8		82	240/15
9		80	240/15
10		70	240/16
11		71	240/12
12		43	240/28
13		93	240/12
14		46	240/12
15		68	210/8
16	$CH_3CH_2NHCH_2CH_2CH_2NH_2$	80	240/15
17	$CH_3NHCH_2CH_2CH_2NH_2$	74	240/12
18	 n= 50 to 500	90	175/8

After cooling and evaporation of the half volume of water, aminophosphosphonic acid crystallised as a white solid. It was then recrystallised in a water-isopropanol mixture. The activation by microwaves allows better yields than a conventional heating.
The aminophosphonic acids were identified by their ^{1}H, ^{13}C, ^{31}P NMR spectra and by microanalysis**.**

CONCLUSION

The one-pot synthesis of polyaminophosphonic acids under microwave irradiation is general, simple, fast, efficient and allows obtaining interesting aminophosphonic acids useful as biologically active molecules, coordinating agents of metals or precursors of materials (organic or MOF).

ACKNOWLEDGEMENTS

We gratefully acknowledge the ‘‘PunchOrga’’ Network (Pôle Universitaire Normand de Chimie Organique), the ‘‘Ministère de la Recherche et des Nouvelles Technologies’’, CNRS (Centre National de la Recherche Scientifique), the ‘‘Région Basse-Normandie’’, the European Union (FEDER funding) and CMEP-TASSILI for their financial support.

REFERENCES

[1] Kukhar, V. P.; Hudson, H. R. *Aminophosphonic and Aminophosphinic Acids, Chemistry and Biological Activity*; J. Wiley & Sons Ltd: New York, **2000**.

[2] a) Abderrahim, O.; Didi, M.A.; Moreau, B.; Villemin, D. *Solv. Extract. Ion Exchange*, **2006**, *24*, 943; b) Belkhouche, N.E.; Didi, M.A.; Romero, R.; Jönsson, J. Å.; Villemin, D. *J. Membr. Sc.,* **2006***, 284*, 398 and references cited.

[3] Morin, C.J.; Carli, M.; Rifaï, R. Al; Jaffrès, P.A.; Villemin, D.; Desbène, P.L., *Chromatographia*, **2005**, *62*,139.

[4] (a) Demadis K.D. ; Katarachia, S.D.; Koutmos, M. K.M.. *Inorg. Chem. Comm.* **2005**, *8* , 254 (b) Demadisa, K.D., Papadakia M., Raptisb R.G., Zhaob, H. *J. Solid State Chem.* **2008***, 181*, 679 (c) Amar H., Benzakour J., Derja A., Villemin D., Moreau B. *J. Electroanal. Chem.* **2003**, *558*, 131 (d) Amar H., Braisaz T.,Villemin D., Moreau.B. *Mat. Chem. Phys*. **2008**, *110*, 1.

[5] Sopkova de Oliveria Santos, J.; Montouillot, V.; Fayon, F.; Fernandez, C.; Delain-Bioton, L.; Villemin, D.; Jaffrès, P.A. *New J. Chem*., **2004**, *28*, 1244.

[6] Turner, A.; Jaffrés, P.A.; MacLean, E.J.; Villemin, D.; McKee V.; Hix, G.B. *J. Chem. Soc. Dalton Trans.,* **2003**, 1314; Kong, D; Zon, J.; McBee,J.; Clearfield, A, *Inorg. Chem*. **45**, **2006**, 977 and references cited.

[7] Villemin, D. ; Moreau, B. ; Siméon, F ; Maheut, G. ; Fernandez, C. ; Montouillout, V. ; Caignaert, V. and Jaffrès, P.A. *J. Chem. Soc. Chem. Commun.*, **2001**, 2060.

[8] a) Mutin, P. H; Guerrero, G.; Vioux., A. *C. R. Chim.*, **2003**, 6, 1153; b) 5 [9] Georgelin, T.; Moreau, B; Bar, N.; Villemin, D.; Cabuil, V.; Horner, O. *Sensors and Actuators B*, **2008**, *134*, *451.*

[10] (a) Kabachnik, M. I.; Medve, T. Y. *Dokl. Akad. Nauk SSSR*, **1952**, *83*, 689; Chem. Abstr. **1953**, *47*, 2724b. (b) Fields, E. K. *J. Am. Chem. Soc*.**1952**, *74*, 1528**.** (c) Redmore, D. *Topics in Phosphorus Chemistry*; Grifith, E. J., Grayson, M., Eds.; John Wiley & Sons: New York, **1976**; (d) Cherkasov, R. A.; Galkin, V.I. *Russ. Chem. Rev*., **1998**, *67*, 857. (e) Fields, S. C. *Tetrahedron*, **1999,** *55*, 12237. (f) Moonen, K., Laureyn, I.; Stevens, C. V. *Chem. Rev*., **2004**, *104*, 6177.

[11] Villemin, D.; *Proceedings of the First International Conference on Microwave Chemistry*, Prague, Czeck Republic, **1998**.

[12] Moedritzer, K.; Irani, R. *J. Org. Chem*. **1996**, *31*, 1603.

[13] a) Lidström, P.; Tierney , J.P. editors, *Microwave-Assisted Organic Synthesis*, Blackwell, Oxford, **2005**. b) Loupy, A. editor, *Microwaves in Organic Synthesis*, Wiley-VCH, Weinheim, **2006**.