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CO_2 Adducts of the Amino and Imino Groups Studied by ^{1}HNMR and ^{13}CNMR

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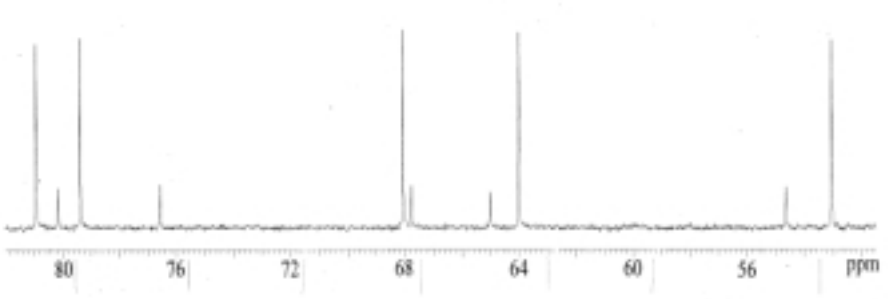
Abstract: CO_2 adducts of *L*-(+)-asparaginic acid and some polyhydroxylated alkaloids was studied by ^{1}HNMR and ^{13}CNMR in this paper.

Keywords: Carbamate, CO_2 adduct, ^{13}CNMR, ^{1}HNMR, polyhydroxylated alkaloid.

When isolating 1,4-dideoxy-1,4-imino-*D*-arabinitol using Dowex 1×2 (OH^- form) or CM-Sephadex C-25 (NH_4^+ form), we found another compound always accompanied with it. It was apparent that the two compounds had similar structures from their ^{1}HNMR and ^{13}CNMR in D_2O (**Fig. 1**). At first, we guessed the two compounds were isomerides. But when acid was added into the solution of the two compounds, the signals for the minor compound disappeared.

Figure 1 ^{13}CNMR of 1,4-dideoxy-1,4-imino-*D*-arabinitol **3** and its carbamino adduct **4**

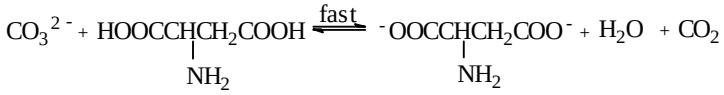


Since certain amines can react with CO_2 to form carbamates[1,2], and the reaction can be conducted by addition of CO_2 or $NaHCO_3$ and Na_2CO_3, we inferred that one of the two compounds was the CO_2 adduct of another.

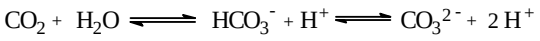
In order to confirm the inference, we added excess K_2CO_3 into the solution of *L*-(+)-asparaginic acid in D_2O. Its ^{1}HNMR and ^{13}CNMR spectra are changed as shown in **Table 1**. This addition results in the partial conversion of *L*-(+)-asparaginic acid to the adduct form by a series of equilibria (**Scheme 1**):

Scheme 1

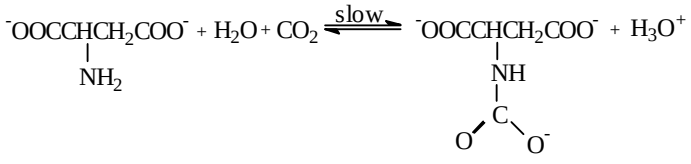
（1）



（2）



（3）



1 **2**

Table 1 ^{1}HNMR and ^{13}CNMR of L-(+)-asparaginic acid and its carbamate

Sample	^{1}HNMR (ppm)	^{13}CNMR(upfield region) (ppm)
L-(+)-asparaginic acid	2.62 (q, J_{AB}=16.9Hz, J_{AX}=7.7Hz)	37.2, 54.0
	2.73 (q, J_{AB}=16.9Hz, J_{BX}=4.2Hz)	
	3.77 (q, J_{AX}=7.7Hz, J_{BX}=4.2Hz)	
1	2.42 (q, J_{AB}=14.8Hz, J_{AX}=8.8Hz)	43.8, 56.5
	2.64 (q, J_{AB}=14.8Hz, J_{BX}=4.8Hz)	
	3.56 (q, J_{AX}=8.8Hz, J_{AX}=4.8Hz)	
2	2.54 (q, J_{AB}=14.7Hz, J_{AX}=8.3Hz)	42.4, 57.4
	2.66 (q, J_{AB}=14.7Hz, J_{AX}=5.1Hz)	
	4.19 (q, J_{AX}=8.3Hz, J_{BX}=5.1Hz)	

In the ^{1}HNMR spectra, δ 2.42, 2.64 and 3.56 correspond to **compound 1** and its protonated adduct; δ 2.54, 2.66 and 4.19 correspond to **compound 2** and its protonated adduct.

When excess CO_2 was added to the equilibrium system, carbamino adduct **2** of L-(+)-asparaginic acid broke down and the pH value was decreased.

In order to confirm the carbamate formation further, we mixed ethanolamine with 0.5eq $KHCO_3$ in D_2O to observe the change of the ^{1}HNMR. The ^{1}H chemical shift values are shown in **Table 2**. The result demonstrates the formation of carbamino adduct of ethanolamine.

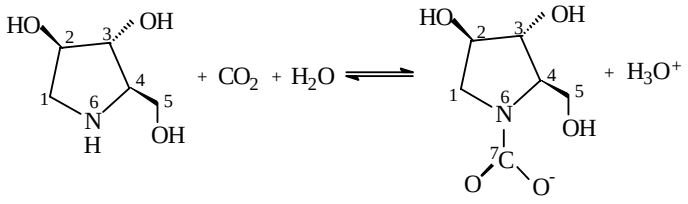
Table 2 ^{1}HNMR of ethanolamine with 0.5eq $KHCO_3$ system

Sample	^{1}HNMR
Ethanolamine	2.74, 3.55
ethanolamine carbamate	3.11, 3.59

When polyhydroxylated alkaloids 1,4-dideoxy-1,4-imino-*D*-arabinitol (**3**) and 1,4-dideoxy-1,4-imino-*L*-xylose reacted with CO_2, the corresponding carbamates formed very easily. In the process of purification of these two compounds using Dowex 1×2 (OH^- form) or CM-Sephadex C-25 (NH_4^+ form), both of them yielded carbamate due to reaction with CO_2 in the air.

1,4-Dideoxy-1,4-imino-*D*-arabinitol **3** reacted with CO_2 to form carbamate **4** as shown in **Scheme 2**:

Scheme 2



3 **4**

The chemical shift values of 1,4-dideoxy-1,4-imino-*D*-arabinitol **3** and its carbamino adduct **4** were changed after addition of CO_2 and $KHCO_3$ into the system (**Table 3**).

Table 3 The change of chemical shift values of the ^{13}CNMR spectra of 1,4-dideoxy-1,4-imino-*D*-arabinitol **3** and its carbamino adduct **4** after addition of CO_2

carbon	1,4-dideoxy-1,4-imino-*D*-arabinitol **3**			carbamino adduct **4**		
	with CO_2 δ (ppm)	without CO_2 δ (ppm)	Δδ (ppm)	with CO_2 δ (ppm)	without CO_2 δ (ppm)	Δδ (ppm)
C-1	52.875	53.039	-0.164	54.918	54.646	0.272
C-2	61.942	63.997	-2.055	65.294	65.029	0.265
C-3	69.358	68.056	1.302	68.057	67.768	0.289
C-4	77.316	79.370	–2.054	76.896	76.583	0.313
C-5	78.762	80.924	-2.162	80.457	80.154	0.303

The proportion of carbamino adduct **4** increased after addition of CO_2 into the system, but the effect was not obvious for the carbon chemical shift of carbamino adduct **4**. All the chemical shift value changes of five carbons were within the range of 0.27~0.31 ppm. The compound **3** can be protonated with the addition of CO_2. The three β-carbons (C-2, C-3 and C-5) of imino group shifted to upfield because of electronic field effect. The chemical shift of C-4 shifted to downfield, because the protonated imino group increased the induction effect, but the electronic field effect was

very small.

By addition of $KHCO_3$ after introducing CO_2 to the system, the proportion of carbamino adduct **4** increased further, but the chemical shift values of the above five carbons showed almost no change, the pH value of the system also showed practically no change.

Surprisingly, when polyhydroxylated piperidine compounds 1-deoxynojirimycin and fagomine were mixed with CO_2 under the same conditions, no detectable adducts were observed.

Acknowledgments

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References and Notes

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