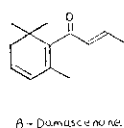


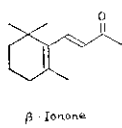
Synthesis and odor of butenoylbicyclo[2,2,1] heptene derivatives

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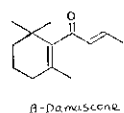
Recently the Firmenich group isolated β -damascenone from Bulgarian rose oil and also β -damascone from Burley tobacco oil.^{1, 2} Although these compounds are isomers of ionones, they are reported to possess a strong rosy smell. These compounds have received much attention as important ingredients in modern perfumery. On the other hand, Cookson reported δ -damascone (1) has an odor reminiscent of β -damascenone. Nevertheless it is actually an isomer of β -damascone.^{3, 4}



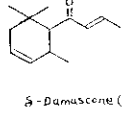
α -Damascenone



β -Ionone

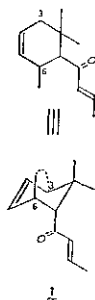


β -Damascone

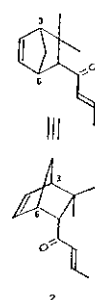


δ -Damascone (1)

Based upon the relationship between molecular structure and organoleptic properties, we have been interested in 2, 2, 4dimethyl-3-butenoylbicyclo[2,2,1]heptene derivatives. It has a structure such that a new bond is formed between the methyl group at C6 position and the methylene at C3 position in compound (1), resulting in fixing of the cyclohexene ring in compound (1) to a complete boat form. Therefore, it seems to be an attractive problem to synthesize



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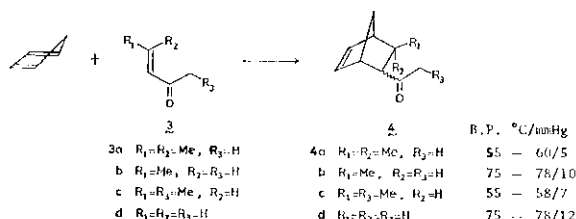


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and know the odor of compound (2) and its derivatives.

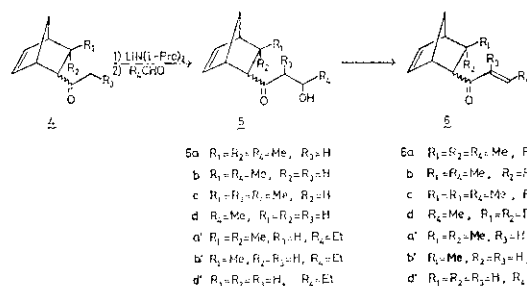
The synthesis was started with Diels-Alder reaction between cyclopentadiene and some α , β -unsaturated ketones as follows.

The dienophiles used were mesityloxide (3a), 3-penten-2-one (3b), 2-hexen-4-one (3c), and methylvinylketone (3d). Except in the case of methylvinylketone, stannic chloride was used as



a catalyst. For example, the least reactive dienophile, mesityloxide, was reacted with cyclopentadiene in methylene chloride at a temperature between -15 and 0°C in the presence of stannic chloride to give the corresponding adducts (4a).⁵ The structures of these adducts (4a-d) were established by spectral properties. The stereochemistry, endo and/or exo ratio, was examined by inspecting the NMR spectrum. Pure endo and exo isomers were isolated by a combination of preparative GC and column chromatography when needed. In the absence of Lewis acid, the endo products were mainly formed and in the presence of catalyst exo isomers appeared as the main components.

These Diels-Alder adducts are then converted to the corresponding butenoyl derivatives by a usual method.³ After a metalation using lithium diisopropylamide in THF at -60°C, several aldehydes such as acetaldehyde, propionaldehyde and crotonaldehyde were reacted to give ketoalcohol (5), which was in turn dehydrated by the treatment of p-toluenesulfonic acid to yield 2-butenoyl bicyclo[2,2,1]heptene derivatives (6).



The geometrical configuration in the butenoyl group of (6) was found to be exclusively trans on the basis of the large coupling constant ($J=11.0$ Hz). Under these reaction conditions, enolization at C2 position was not observed, and the GC and NMR spectra indicated that the endo/exo ratio in the starting materials (4) was retained in the product (6).

Table I shows a few properties and the odor of the 2-butenoylbicyclo[2,2,1]heptene derivatives (6). It was noticed that compound 6a, especially the endo derivative of compound 6a, showed a pleasant floral note as expected. The geminal dimethyl group at C₃ position is important and essential, because the demethylated compounds 6b, 6c and 6d lose the sweet floral note in the endo 6a.

Table I. Butenoyl bicyclo (2,2,1) heptenes

	R ₁	R ₂	R ₃	R ₄	B.P. °C/mmHg	Odor
6a	Me	Me	H	Me	78 - 80/1	Fruity, Floral
6a'	Me	Me	H	Et	85 - 87/1	Woody
6b	Me	H	H	Me	97 - 98/5	Fruity green
6b'	Me	H	H	Et	86 - 88/1	Fruity
6c	Me	H	Me	Me	98/3	Maple like
6d	H	H	H	Me	101 - 103/11	Bitter green, Fruity
6d'	H	H	H	Et	108 - 110/6	Fruity

Successively the dihydro derivatives of 2-butenoylbicyclo[2,2,1]heptene (6) were synthesized to clarify a role of the double bond in relation to the organoleptic properties. They were prepared by applying the same method as the previous unsaturated series starting from the 2-substituted-3-acylbicyclo[2,2,1]heptanes which were obtained by catalytic hydrogenation of compound (4). During these reactions, the endo-exo epimerization was not observed.

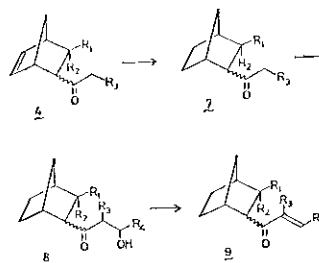


Table II. Butenoyl bicyclo (2,2,1) heptanes

	R ₁	R ₂	R ₃	R ₄	B.P. °C/mmHg	Odor
9a	Me	Me	H	Me	72 - 73/1	Fruity woody
9a'	Me	Me	H	Et	106 - 108/2	Woody
9b	Me	H	H	Me	95 - 97/5	Sweet woody
9b'	Me	H	H	Et	113 - 115/2	Sweet, Waxy
9c	Me	H	Me	Me	100/3	Woody, Floral
9d	H	H	H	Me	99 - 101/5	Floral
9d'	H	H	H	Et	118 - 120/6	Sweet balsamic

Some physical and organoleptic properties of these compounds (9) are tabulated in Table II.

The dihydro derivative (9a) possesses a more distinct fruity odor compared to that of the dehydroderivatives (6a).

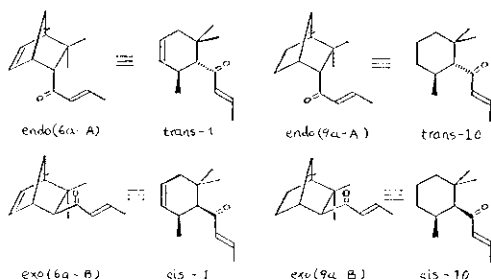
Discussion

In comparing the odor of the endo isomer (6a-A) with that of the corresponding exo isomer (6a-B), the endo compound has a rosy floral note with a fruity tone whereas the exo compound produces a camphorous note. When the bonds shown by the wavy line are cleaved as in (6a-A) or (6a-B), trans- and cis- δ -damascones are formed respectively. The endo isomer (6a-A) corre-

sponds to trans δ -damascone and the exo isomer (6a-B) to cis δ -damascone.

According to the report of Cookson, the δ -damascone (1) is a mixture of the trans and cis derivatives, in which the cis derivative is predominant (90:10).³ To our knowledge, however, the organoleptic properties of trans-1 and cis-1 are not cited in the literature. Therefore we repeated Cookson's experiments and found that the trans isomer had a rosy and fruity odor while the cis isomer indicated a camphorous note. This phenomenon is consistent with the odor tendency of the 2,2-dimethyl-3-butenoylbicyclo[2,2,1]heptene (6a).

On the other hand, DeHaan compared the odors of stereoisomers of 2,2,6-trimethylcyclohexylbutenone (10), a dihydroderivative of damascone.⁶ He concluded that the trans isomer had a strong and warm natural fruity odor and was very useful and valuable as a flavor. This observation is in agreement with our finding that the dihydroderivative (9a) has a fruity odor and the endo isomer (9a-A), which corresponds to trans isomer (trans-10), is more valuable as a flavor than exo isomer (9a-B).



In conclusion, it should be emphasized that 2,2-dimethyl-3-butenoylbicyclo[2,2,1]heptene and -heptane derivatives have a very similar odor tendency in their organoleptic properties to the corresponding 2,2,6-trimethylcyclohexenyl and -hexyl derivatives.

Summary

Several butenoylbicyclo[2,2,1]heptene and -heptane derivatives were synthesized and their odor was noted. Based on stereochemistry, the odor of 2,2-dimethyl-3-butenoylbicyclo[2,2,1]heptene and -heptane were compared with the corresponding 2,2,6-trimethylcyclohexenyl and -hexyl derivatives.

Acknowledgment

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