Amphiphiles with different chemical structures and arrangement of hydrophilic and hydrophobic groups have been reported, and their structural features determine the morphological and functional properties of those self-assemblies formed in water.[15] The formation of vesicles from monoalkylphenol derivatives is in theory unexpected because of the conelike shape of the molecules and the high pK_a value of the OH groups. In fact, alkylresorcinol **3**, which has an alkyl chain as long as that in **1** and **2** but lacks a macrocyclic structure, forms micellelike aggregates under conditions identical to those described here. Aggregates of **3** with diameters less than 16 nm were confirmed by AFM.[16] In contrast, owing to the macrocyclic structures of **1** and **2** composed of four alkylresorcinol and alkylpyrogallol moieties, respectively, the amphiphiles have a cylindrical shape, and thus vesicles are the preferred morphology of aggregates formed in water.

The FT-IR spectrum of the dehydrated vesicles of **1** shows the stretching band of the hydrogen-bonded OH groups (3500 cm^{-1}).[17] A pair of hydroxyl groups on adjacent benzene rings form a hydrogen bond due to their proximity, which stabilizes the all-axial and all-*cis* configuration, and probably promotes the dissociation of one OH group in the pair at the experimental pH. This also suggests the existence of intermolecular OH $\cdots$ O hydrogen bonds. This phenomenon along with the shape of the amphiphile and hydrogen bonds in **1** and **2** should help stabilize the vesicle structure. To the best of our knowledge this is the first example in which a phenolic surfactant self-assembles to furnish a vesicle.

We have shown that a macrocycle consisting of four phenolic amphiphiles and having a cylindrical molecular shape self-assembles selectively to form a vesicle. The intra- and intermolecular hydrogen bonds between OH groups on **1** and **2** play an essential role in stabilizing the assembled structure. This work, therefore, may open the way for the study of calixarenes in assembled form, in contrast to previous studies dealing mainly with their unimolecular function.

Received: November 24, 1997
Revised version: October 26, 1998 [Z 11191 IE]
German version: *Angew. Chem.* **1999**, *111*, 565 – 567

Keywords: calixarenes · hydrogen bonds · self-assembly · vesicles

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[6] Electron micrographs were recorded on JEOL TEM-2000F and TEM-1010 instruments. The freeze-fracture replicas were fabricated with a JEOL JFD-9010 instrument.

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[9] The vesicle solution (2.5×10^{-3} M, 4 mL) containing a fluorescent dye (sodium 8-amino-1,3,6-naphthalenetrisulfonate, 34.2 mg) was separated with Sephadex G-50 (1 cm $\times$ 20 cm) using the buffer as the eluent. The vesicles were obtained in the 0.36 – 0.63 mL fraction, whereas the free dye was obtained after elution of 0.9 mL. The vesicle fraction fluoresced at 515 nm when irradiated at 370 nm.

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Adsorption of Acetone onto MgO: Experimental and Theoretical Evidence for the Presence of a Surface Enolate**

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Basic catalysts are widely used in heterogeneous catalytic processes either as supports or active components. Among these processes, aldol condensation of ketones is of out-

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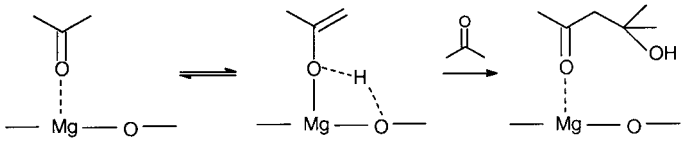
[**] This work was supported by the DGICYT (Spain, project no. PB95-1247) and by the European Commission (contract no. ERBCT1-CT94-0064).

  1433-7851/99/3804-0506 $ 17.50+.50/0

standing industrial interest. For example, aldol addition of acetone gives diacetone alcohol (DAA), which is used as a cellulose solvent and also as an intermediate in the synthesis of methyl isobutyl ketone, an important solvent in the chemical industry. From a mechanistic point of view, aldol additions are base-catalyzed reactions which occur through formation of an enolic species on a basic center of the MgO surface, which then adds to a C=O double bond to yield DAA (Scheme 1).



Scheme 1.

Although the catalytic activity of MgO is lower than other more basic solids, such as heavier alkaline earth oxides[1] or aluminum phosphorous oxinitrides catalysts,[2] its well-known structure makes it suitable for mechanistic studies.[3] In fact, the acetone–MgO system has been the subject of several infrared and temperature-programmed desorption studies,[4] and $^1H-^2H$ exchange experiments have also been reported.[5] Despite all this work, some aspects of the surface reaction still remain open. In particular, the $^1H-^2H$ exchange studies suggested a slow formation of the C–C bond by reaction of the enolate species with acetone. However, no spectroscopic evidence for the presence of an enol species on the MgO surface has been reported. This could, in principle, be due to poor resolution of the earlier IR spectra, and we were prompted to revisit this system using a much more sophisticated tool based on diffuse reflectance Fourier transform techniques (DRIFT). Such a study was found to be of increased interest when a recent theoretical paper was taken into account.[6] The effect of a MgO surface on the keto–enol equilibrium for acetone was shown to significantly decrease the energy difference between the keto and enol tautomers. Such a stabilization of the enol tautomer necessarily involves an increment of its surface concentration, which would account for the catalytic activity of the surface.

With the aim of investigating the presence of an enolic tautomer on the MgO surface, we undertook a DRIFT spectroscopic study of the acetone–MgO system. The most outstanding result is the appearance of a new band at 1640 cm^{-1} which could be assigned to an adsorbed enolic species. To support this interpretation, theoretical calculations of the vibrational frequencies for acetone and isopropenol chemisorbed on a MgO surface have been performed. These computations were carried out by means of second-order Möller–Plesset ab initio Hartree–Fock cluster-embedded calculations.

The DRIFT spectra were recorded with a Nicolet 510P spectrometer equipped with a high-temperature cell with a volume of about 1.5 cm^3 (Spectra-Tech) and ZnSe windows. MgO samples were outgassed in situ at 500 °C under a flow of nitrogen. The spectrum of such a sample was taken as the reference for the later enhancement of the contribution of adsorbed species. Nitrogen gas was bubbled through a saturator which contained acetone at 25 °C; this stream was then admitted into the DRIFT cell. In Figure 1 b, the spectrum

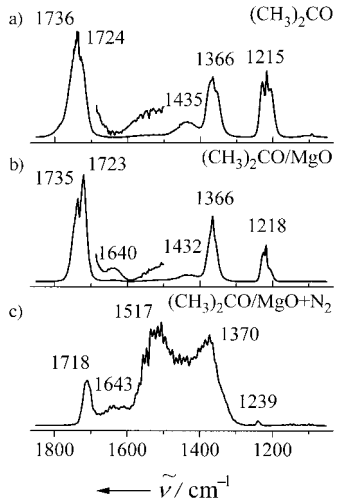


Figure 1. Experimental room-temperature DRIFT spectra. a) Acetone in the gas phase. b) MgO in contact with dry N_2 and acetone vapor. c) After outgassing in a dry N_2 flow. Intensities in arbitrary units.

of the adsorbed phase, recorded in a flow of acetone, is reported in the 800–2000 cm^{-1} region. For comparative purposes, the spectrum of gas-phase acetone recorded under the same conditions is reported in Figure 1 a. In this case, the intensity of the interferogram was ratioed to the signal which corresponded to an aluminum mirror. When these spectra are compared, they appear quite similar. In the acetone–MgO system, two bands are observed in the CO stretching region (1735 and 1723 cm^{-1}), in agreement with high-resolution spectra of ketones. These two peaks are generally explained by a Fermi resonance between the fundamental CO vibration and an overtone. The shift of these frequencies with respect to the gas-phase IR spectrum (1739, 1724 cm^{-1}) is negligible and within the resolution of the instrument (4 cm^{-1}), which indicates weak physisorption of an electrostatic nature between the acetone molecule and the surface, in agreement with previous theoretical work.[6] This band is followed by a small shoulder at 1640 cm^{-1} which is not present in the gas-phase spectrum of acetone and is clearly appreciable in the overlayed spectrum obtained after amplification by a factor of ten. The intense bands in the 1437–1365 cm^{-1} region correspond to symmetric and asymmetric bending vibrations of methyl groups, while the 1207–1225 cm^{-1} absorption bands are commonly assigned to C-C-C stretching vibrations. In summary, both spectra are similar, with the exception of the 1640 cm^{-1} band, whose presence suggests the formation of a new surface species. It should be noted that this band is observed in a relatively wide range of experimental conditions, from room temperature up to 140 °C. At higher temperatures, new signals which correspond to addition products are observed.

A further point was to determine whether this band is due to a species directly adsorbed on the surface or if it is due to a species present in a possible multilayer. Therefore, acetone

  1433-7851/99/3804-0507 $ 17.50+.50/0

was flushed out of the cell by a dry N_2 flow. Under these conditions, it is expected that only strongly adsorbed species will remain. As shown in Figure 1 c, the spectrum is dominated by the strong absorption bands of carboxylate-like species[7] which arise from the well-known oxidation reaction of acetone on metal oxide surfaces;[8–10] the 1640 cm^{-1} band is still present, however. This band cannot be assigned to the water-bending mode since, firstly, the spectra are displayed with MgO under the same conditions as the reference. Secondly, inspection of the OH region of the spectrum shows that the band associated to hydrogen-bridged OH groups has a very low intensity and it is known that the intensity of the water-bending vibration is even less intense. Moreover, this band could be correlated with those observed in the FT-IR spectra of acetone adsorbed on vanadia-titania (1565 cm^{-1}) and Fe_2O_3 (1540 cm^{-1}) surfaces,[8, 11] and which have been assigned to an enolate species because of their similarity to the band at 1582 cm^{-1} observed in a solution of the sodium salt of malonaldehyde in DMSO.[12]

To attempt a more reliable assignment of this band, ab initio embedded-cluster calculations of the vibrational spectrum for both acetone and isopropenol adsorbed on a MgO (100) surface were undertaken. To model the surface, a $[MgO_5]^{8-}$ cluster embedded in an array of model potentials and point charges was chosen as described in reference [6]. For the Mg^{2+} cation, the basis set proposed by Huzinaga was used,[13] enlarged with two s primitive functions to represent the 3s orbital; the contraction was (9s4p)/[4s2p]. For surface oxygen atoms, the basis set optimized for O^- was chosen, with the (9s5p)/[4s3p] contraction.[14] The standard DZP basis set was used for the carbon, oxygen, and hydrogen atoms of the adsorbate. In the calculations, surface ions were fixed at their ideal crystallographic positions (d(Mg–O) = 2.105 Å[15]), while the adsorbed acetone or isopropenol geometries were optimized at the MP2 level of theory.[16] The equilibrium geometries are reported in Figure 2. As can be seen, acetone

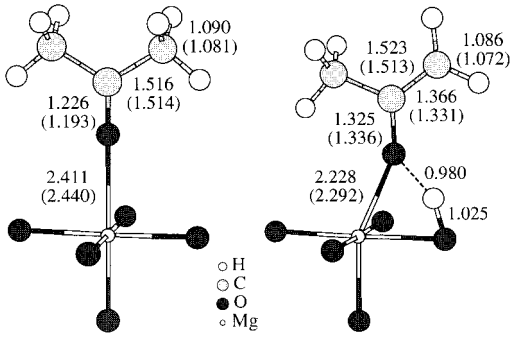


Figure 2. Selected optimized structural parameters for acetone (left) and isopropenol (right) adsorbed on a MgO (100) surface obtained from ab initio MP2 embedded-cluster calculations. Values in parentheses are those obtained at the Hartree–Fock level.

adsorbs with the carbonyl group perpendicular to the surface through interaction between a Mg^{2+} cation and the oxygen atom, with local C_{2v} symmetry. Isopropenol dissociates to give the corresponding enolate and a proton bound to a surface oxygen atom. It should be noted that at the HF level (values in parentheses), the preferred form is the enol instead of the enolate, as previously mentioned,[6] where the enolate was only found when the surface was allowed to relax.

Vibrational frequencies and intensities of infrared bands were then computed, and the results are summarized in Figure 3. The spectrum for the acetone–MgO system is

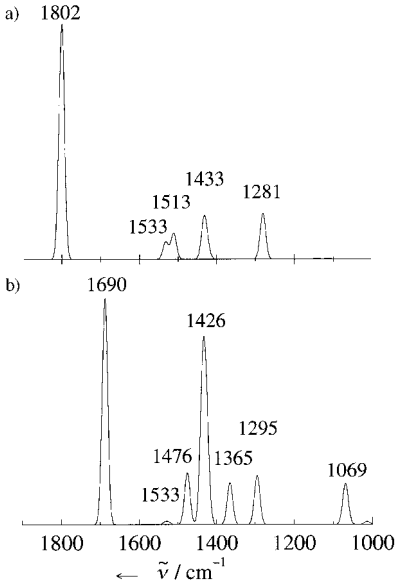


Figure 3. Theoretical IR spectra for a) acetone and b) enolate adsorbed on MgO obtained from ab initio MP2 embedded-cluster calculations. Intensities in arbitrary units.

reported in Figure 3 a, and excellent agreement is found with the experimental spectrum, both in the shape and position of the bands. The theoretical frequencies appear to be somewhat higher, and the differences (50–70 cm^{-1}) agree with the shifts known for the harmonic approximation. Figure 3 b shows the IR spectrum of the enolate–MgO system. The most outstanding feature of this spectrum is the band computed at 1690 cm^{-1} which, after the analysis of its associated normal coordinate, is unambiguously assigned to the asymmetric stretching vibration of the C-C-O group. The second most intense peak appears at 1426 cm^{-1} and corresponds to the symmetric stretching vibration mixed with some methyl bending, and, although its intensity is considerable, it would be buried by the bands of acetone and acetate present in this region of the experimental spectra. This frequency agrees with those observed at 1380 cm^{-1} in the acetone/vanadia-titania spectrum [8] and 1374 cm^{-1} in the malonaldehyde sodium salt spectra.[12]

In summary, the present work shows that acetone adsorption on MgO gives rise to a band at 1640 cm^{-1} in the DRIFT spectrum that, based on a careful theoretical analysis, is assigned to a surface enolate species. This assignment also confirms the proposed origin of the bands observed in the FT-IR spectra of acetone adsorbed on titanium and iron oxides at 1565 and 1540 cm^{-1}. The frequency shift of these bands with respect to the one reported here can be easily understood because, according to our models, the interaction between both acetone and enolate with the surface occurs through coordination of a surface metal center and the oxygen of the

  1433-7851/99/3804-0508 $ 17.50+.50/0

adsorbed molecule. Because of the stronger Lewis character of Ti^{IV} and Fe^{III} centers, a larger adsorbate-surface interaction and, consequently, a weakening of the C–O and C-C-O bonds can be expected.[17] Finally, the existence of such an enolate species seems to confirm that the acetone surface condensation reaction occurs through a standard aldol mechanism.

Received: July 1, 1998
Revised version: November 16, 1998 [Z12080IE]
German version: *Angew. Chem.* **1999**, *111*, 567 – 570

Keywords: ab initio calculations · enols · heterogeneous catalysis · IR spectroscopy · surface chemistry

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Chemo-Enzymatic Synthesis of Fluorescent Rab 7 Proteins: Tools to Study Vesicular Trafficking in Cells**

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Proteins that are S-farnesylated and S-geranylgeranylated at C-terminal cysteine residues play critical roles in cell processes such as signal transduction and intracellular trafficking.[1–3] Although our understanding of the biological consequences of protein prenylation has increased significantly over the last few years, there is still relatively little known about the molecular details that govern its functional role, for instance in vesicular trafficking. A particularly relevant example is the role of the Rab proteins in intracellular membrane trafficking. The Rab proteins are a group of small G-proteins that associate with specific membrane components. They are believed to control the events of docking and fusion of intracellular vesicles.[4] Rab proteins are subjected to geranylgeranylation through a process that involves Rab geranylgeranyltransferase (RabGGTase) and an accessory protein termed a Rab escort protein (REP). Thus, in order to undergo prenylation, a newly synthesized Rab protein must bind and form a stable complex with REP, which only then (in contrast to other known prenyltransferases) is recognized by RabGGTase.[5, 6] Upon prenylation the Rab protein remains bound to REP and accompanies it to the corresponding membrane.[7] Subsequent REP-mediated membrane insertion of prenylated Rab proteins is believed to proceed through a putative membrane receptor. The free REP protein is then released and can support another round of Rab prenylation.

Unfortunately, very little is known about the molecular details of this general scenario. Major questions such as whether the lipid groups participate in protein – protein recognition, or the exact mechanism by which the lipidated Rab/REP complex is directed to specific intracellular compartments remain unanswered. Furthermore, despite a number of related reports, the exact affinities of RabGGTase for its lipid substrate are unknown, and the reaction mechanism of the prenylation reaction is also unelucidated. Specific fluorescent probes should enable the dissection of the reaction mechanism through the use of fluorescent spectroscopy. Such probes would allow real-time imaging of the

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[**] This research was supported by the Deutsche Forschungsgemeinschaft and the Fonds der Chemischen Industrie. D.J.O. gratefully acknowledges financial support from the Alexander von Humboldt Foundation in the form of a postdoctoral fellowship.

  1433-7851/99/3804-0509 $ 17.50+.50/0