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Chiral pyridinium-based ionic liquids containing the (1*R*,2*S*,5*R*)-(−)-menthyl group

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Abstract—A novel class of chiral pyridinium salts in which the chirality resides in the cation have been prepared and characterized. The physicochemical and anti-microbial properties have been determined. The group of prepared salts contained chiral ionic liquids and decomposable chiral pyridinium chlorides.

1. Introduction

Pyridinium salts possess surface-active properties, detergency, biological activities (in particular, anti-bacterial activity), and a capacity to be adsorbed on negatively charged solids. The most important pyridinium derivatives occurring naturally are those of nicotinamide, which have a coenzyme function. The most general method of forming pyridinium halides is by nucleophilic substitution, sometimes called the Menschutkin reaction.[1] Pyridinium halides are used as synthetic precursors of ionic liquids (ILs). ILs open up a wide field for future investigations in chemistry, electrochemistry, biology, physics, material science, and medicine. Recently, some chiral ionic liquids (CILs) have been reported and a review of this newest class is available.[2,3] CILs are particularly attractive due to the potential for their chiral discrimination, as in asymmetric synthesis and the resolution of racemates. From a structural point of view, chirality in ILs can arise from either the anion or the cation. Two examples of CILs containing the (1*R*,2*S*,5*R*)-(−)-menthyl group as (1*R*,2*S*,5*R*)-(−)-menthylammonium and (1*R*,2*S*,5*R*)-(−)-menthylimidazolium have been published.[4,5] The preparation, characterization, and the single-crystal X-ray structures of trialkyl[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]ammonium salts have been reported.[4] 3-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]-1-methylimidazolium bis(trifluoromethanesulfonyl)imide has been successfully used as a chiral solvent in the photoisomerization of dibenzobicyclo[2.2.2]octatrienes.[5] Chloromethyl (1*R*,2*S*,5*R*)-(−)-menthyl ether as a chiral OH protecting group was used in the measurement of enantiomeric excess.[6,7] Herein, we report new chiral pyridinium-based ILs with a (1*R*,2*S*,5*R*)-(−)-menthyl substituent in the 1 position of the pyridine ring.

2. Results and discussion

All pyridinium salts were prepared in the two step reaction presented in Scheme 1. The first step was the Menschutkin reaction. As a reagent for quaternization, chloromethyl (1*R*,2*S*,5*R*)-(−)-menthyl ether was used, which was obtained from (1*R*,2*S*,5*R*)-(−)-menthol, the inexpensive, commercially available (−)-isomer. This ether is very reactive. It requires strictly anhydrous conditions, since, otherwise it readily becomes hydrolyzed to HCl, CH_2O, and menthol. Quaternization takes place immediately and proceeds readily at room temperature via an S_N1 mechanism. The initial rate-determining step is cation formation by ionization. The obtained cation rapidly reacts with pyridine derivatives. This specific type of Menschutkin reaction is presented in Scheme 2. In general, the procedure is simple and the reaction has high product yield. Synthesized pyridinium chlorides **1**, presented in Table 1, are crystalline, except **1f** which is a hygroscopic grease. They are easily soluble in water, except **1i** which is poorly soluble and can be assayed by a direct two-phase back titration according to the EN ISO 2871-1 (2000) standard. The results of surfactant content studies are listed in Table 1 and ranged from 92.5% to 99.5% surfactant content. The remainder

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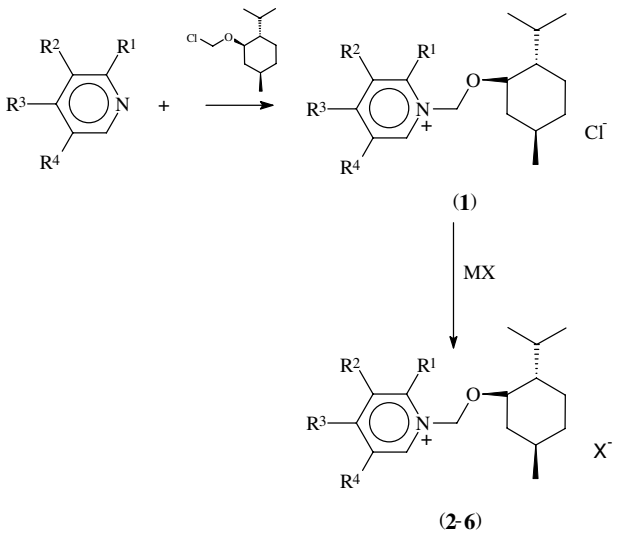
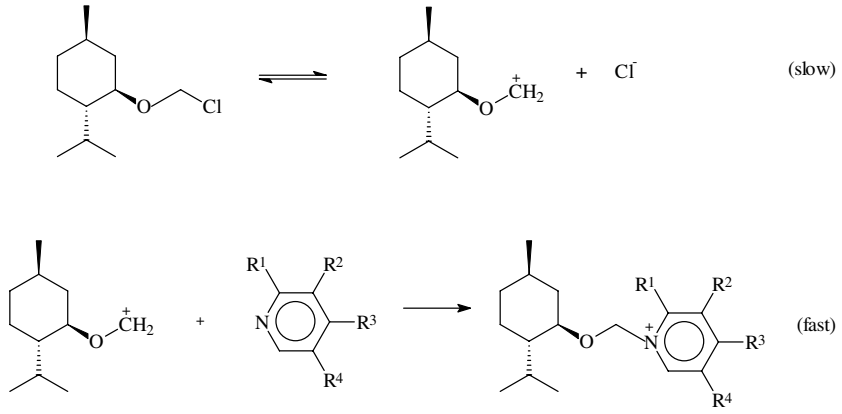


Scheme 1.

was essentially water since the chlorides were hygroscopic. The yield, melting point, and specific rotation of each salt are presented in Table 1. The chirality resided in the cation.

The synthesized chlorides **1** were stable in air and in contact with water. The only exception was 3-carbamoyl-1-(1*R*,2*S*,5*R*)-(−)-menthylpyridinium chloride **1h**, which easily underwent hydrolysis only above the temperature of 40 °C. The reaction products were found to include nicotinamide hydrochloride, (1*R*,2*S*,5*R*)-(−)-menthol and formaldehyde. In the studied hydrolysis reaction, the change of chloride **1h** concentration at various temperatures is shown in Figure 1. The plots of the natural log of the concentration ($\ln c$) as the function of time represented straight lines. Therefore, it was assumed that it was a first order reaction. The estimated rate constants are listed in Table 2.

The prepared chiral pyridinium chlorides were subsequently employed as synthetic precursors of CILs. The second step of the synthesis involved ion exchange. The obtained [BF_4] **2**, [ClO_4] **3**, [I] **4**, and [PF_6] **5** salts were solids, which could be easily crystallized to form plates or needles with sharp melting points. The melting points and specific rotations of these salts are given in Table 3. The [NTf_2] salts **6**, which were CILs, are listed in Table 4. All the synthesized salts were completely miscible with methanol, ethanol, acetone, DMF, and DMSO. However,



Scheme 2.

Table 1. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]pyridinium chlorides **1**

Chloride	R^1	R^2	R^3	R^4	Yield [%]	Mp [°C]	Surfactant content [%]	Specific rotation[f] $[\alpha]_D^{20}$
1a	H	H	H	H	98.0	105–106[a]	96.5	−124.2 (*c* 0.9)
1b	CH_3	H	H	H	99.0	150–155[a]	97.0	−99.7 (*c* 0.5)
1c	H	CH_3	H	H	99.5	142–145[a]	98.5	−126.9 (*c* 0.6)
1d	H	H	CH_3	H	99.0	106–108[a]	96.5	−117.1 (*c* 1.3)
1e	H	H	C_2H_5	H	98.5	80–81[b]	99.0	−124.8 (*c* 1.0)
1	H	H	*tert*-Bu	H	97.0	Hygroscopic	92.5	−102.7 (*c* 1.3)
1g	CH_3	H	H	OH	98.0	186–189[c]	99.5	−120.9 (*c* 1.1)
1h	H	$CONH_2$	H	H	98.5	145–149[d]	93.0	−122.2 (*c* 1.0)
1i	H	OH	H	H	98.0	202–204[e]	99.0	−147.3 (*c* 1.0)
1j	H	H	$N(CH_3)_2$	H	99.0	192–197[a]	96.5	−117.8 (*c* 0.5)
1k	H	$N(CH_3)_2$	H	H	98.5	118–119[a]	99.5	−154.6 (*c* 1.0)

[a] From ethyl acetate + chloroform; plates.
[b] From hexane + acetone; plates.
[c] From ethyl acetate + ethanol; needles.
[d] Plates.
[e] From ethyl acetate + chloroform + ethanol; needles.
[f] *c* in ethanol.

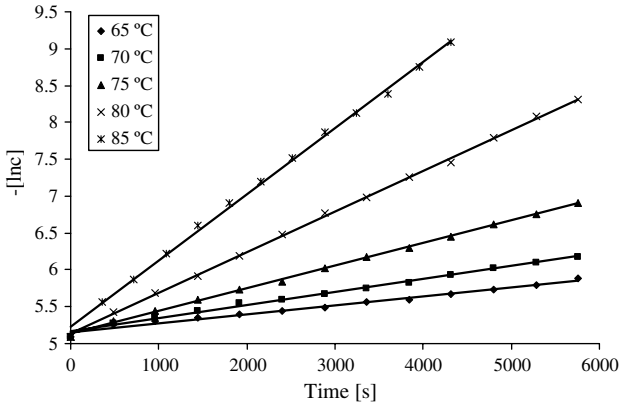


Figure 1. Logarithm of concentration as a function of time for hydrolysis of chloride **1h**.

Table 2. The rate constants of hydrolysis of chloride **1h**

Temperature [°C]	k			R^2
	k [$\times 10^4$]	Standard error [$\times 10^4$]	$\pm\Delta k$ 95% confidence level [$\times 10^4$]	
65	1.6125	0.0594	0.2615	0.9853
70	1.7674	0.0411	0.1892	0.9935
75	3.0728	0.0306	0.1348	0.9989
80	5.5192	0.0470	0.2072	0.9992
85	8.9846	0.1219	0.5367	0.9980

their solubilities in toluene, chloroform, and ethyl acetate strongly depended on the type of anion. For example, [BF_4] salts **2** were soluble in chloroform and [NTf_2] salts **6** exhibited partial miscibility with chloroform. None of the prepared salts dissolved in hexane or diethyl ether.

Anhydrous salts were obtained by heating the products under vacuum. Karl Fischer measurements showed the water content of the dried salts to be less than 200 ppm. The densities of the dry studied ILs are weakly temperature dependent (over 10°, the density decreases by about 2%). The viscosities are strongly influenced by temperature, as presented in Figure 2.

These new pyridinium chlorides were characterized by ^1H and ^{13}C NMR, and by elemental analysis. Comparison of the proton spectra of chlorides **1** with those of salts **2**–**6** indicated differences in the proton chemical shifts as listed in Table 5.

The prepared chiral [Cl] salts **1** were tested for anti-microbial activity. The minimum inhibitory concentration (MIC) and minimum bactericidal or fungicidal concentration (MBC) determined for chiral chlorides **1** are given in Table 6. The tested microorganisms represent cocci, rods and fungi. The activities of these salts were similar, However, no such broad activity was observed as that noted for benzalkonium chloride (BAC), the activity of which is given in Table 6. Chlorides **1** practically remained inactive against fungi (*Candida albicans* and *Rhodotorula rubra*). They proved to be most active against *Micrococcus luteus* and, in the cases of **1i**, **1j** and **1k**, the activity was definitely more pronounced than that of BAC. In general, our previous studies of pyridinium salts with alkoxymethyl or alkylthiomethyl hydrophobic groups show strong and wide antibacterial spectra similar to the activity of BAC.[8,9] The restricted activity observed for most of chlorides **1** can be explained by the absence of a long substituent on the pyridine ring, which was accompanied by a low surface activity.

Previous studies of ozonation of pyridinium salts containing alkoxymethyl or alkylthiomethyl hydrophobic groups produced results strongly dependent on the types and positions of the substituents on the pyridine ring. The most favorable was the third position and HO– or $(CH_3)_2N$ substituents.[10] For the synthesized chiral chlorides **1** at a concentration of 2 g/L, their stability was tested when exposed to ozone in aqueous solution. We conducted the process for 20 min, consistent with practices for the ozone treatment of sewage (10–20 min). Only chlorides **1i** and **1k** reacted with ozone in an aqueous solution. Ozonation was rapid and after 20 min the extent of destruction reached

Table 3. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]pyridinium salts **2**–**5**

Salt	R^1	R^2	R^3	R^4	Anion	Yield [%]	Mp [°C]	Specific rotation[e] $[\alpha]_D^{20}$
2a	H	H	H	H	BF_4	98.5	110–111[a]	−116.5 (*c* 0.7)
2b	CH_3	H	H	H	BF_4	99.0	145–146[a]	−116.3 (*c* 1.0)
2c	H	CH_3	H	H	BF_4	99.0	72–73[a]	−116.9 (*c* 1.0)
2d	H	H	CH_3	H	BF_4	99.0	113–114[a]	−109.9 (*c* 0.7)
2e	H	H	C_2H_5	H	BF_4	98.0	82–84[a]	−112.2 (*c* 1.1)
2f	CH_3	H	H	OH	BF_4	99.0	130–132[a]	−108.9 (*c* 1.0)
2g	H	$CONH_2$	H	H	BF_4	97.5	124–127[b]	−111.9 (*c* 1.0)
2h	H	OH	H	H	BF_4	98.0	101–102[a]	−114.8 (*c* 1.0)
2i	H	H	$N(CH_3)_2$	H	BF_4	99.5	105–107[c]	−112.6 (*c* 1.0)
2j	H	$N(CH_3)_2$	H	H	BF_4	99.5	131–132[a]	−139.4 (*c* 0.5)
3	H	H	H	H	ClO_4	97.0	114–115[d]	−110.9 (*c* 0.6)
4	H	H	H	H	I	90.0	133–135[a]	−50.9 (*c* 0.8)
5	H	H	H	H	PF_6	99.7	140–142[a]	−97.6 (*c* 1.0)

[a] From water + acetone; plates.
[b] From chloroform + acetone; plates.
[c] From water + acetone + ethanol; needles.
[d] From water + acetone; needles.
[e] *c* in ethanol.

Table 4. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]pyridinium bis(trifluoromethanesulfonyl)imides **6**

CIL	R^1	R^2	R^3	R^4	Yield [%]	Mp [°C]	Specific rotation[f] $[\alpha]_D^{20}$	Density[g] [g mL^{-1}]	Viscosity[g] [mPa s]	T_{onset}[h] [°C]
6a	H	H	H	H	86.0	−33.0[a]	−70.9 (*c* 1.4)	1.28	550	180 (390)
6b	CH_3	H	H	H	87.0	−31.4[a]	−77.2 (*c* 1.1)	1.29	839	180 (400)
6c	H	CH_3	H	H	88.0	Grease	−70.3 (*c* 1.3)	—	—	205 (445)
6d	H	H	CH_3	H	87.5	66–67[b]	−71.2 (*c* 1.0)	—	—	205 (410)
6e	H	H	C_2H_5	H	95.5	70–72[c]	−69.7 (*c* 0.5)	—	—	208 (380)
6f	H	H	*tert*-Bu	H	90.0	−23.2[a]	−70.4 (*c* 1.6)	1.30	1003	210 (420)
6g	H	$CONH_2$	H	H	98.0	74–75[d]	−75.4 (*c* 1.2)	—	—	165 (355)
6h	H	$N(CH_3)_2$	H	H	91.0	30–32[e]	−92.5 (*c* 0.85)	—	—	220 (445)

[a] Determined by DSC on heating.
[b] From water + ethanol; plates.
[c] From water + ethanol; plates.
[d] From water + ethanol; needles.
[e] Plates.
[f] *c* in ethanol.
[g] At 50 °C.
[h] Decomposition temperature determined from onset to 50% mass loss.

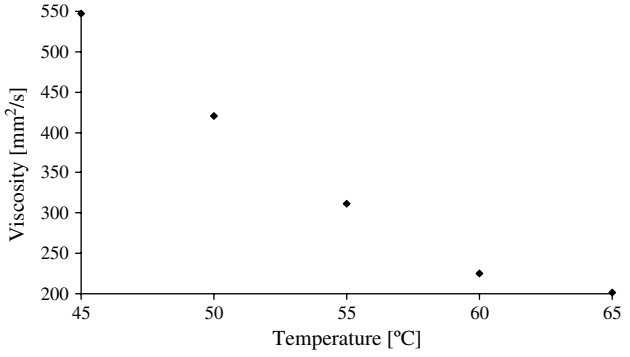


Figure 2. Viscosity of dry CIL **7a** as a function of increasing temperature.

almost 100% (Fig. 3). The extent of destruction was calculated from the relationship:

$$D = (1 - X/X_0) \times 100(\%)$$

where X and X_0 were the concentrations in water after 20 and 0 min, respectively. The prepared chiral chlorides contained compounds which could be quantitatively removed by aqueous ozonation.

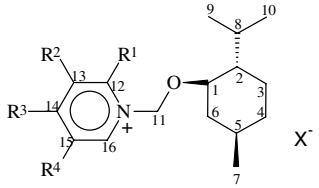
3. Conclusion

With high efficiency, a number of chiral pyridinium salts were prepared. The chirality resided in the cation. The group of prepared salts contained chiral ionic liquids and decomposable chiral pyridinium chlorides. A derivative of vitamin PP, 3-carbamoyl-1-(1*R*,2*S*,5*R*)-(−)-menthylpyridinium chloride easily hydrolyzed, while chlorides with OH and $N(CH_3)_2$ groups in position three on the pyridine ring were susceptible to ozone treatment. The estimated microbiological activity of the obtained salts is of key importance in selection of the appropriate chiral pyridinium salts as media for reactions conducted with the involvement of microbes.

4. Experimental

^{1}H NMR spectra were recorded on a Mercury Gemini 300 spectrometer at 300 MHz with tetramethylsilane as the standard; ^{13}C NMR spectra were recorded using the same instrument, at 75 MHz. Elemental CHN analyses were performed at the A. Mickiewicz University, Poznań. A

Table 5. The shift[a] in proton signals



Salt	X	Characteristic proton			
		HC12 and HC16	HC14	HC13 and HC15	H_2C11
1a	Cl	9.75 (d)	8.81 (t)	8.33 (t)	6.38, 6.51 (d, $J = 10.2$)
2a	BF_4	8.94 (d)	8.60 (t)	8.11 (t)	5.92, 5.96 (d, $J = 10.9$; $J = 10.7$)
3	ClO_4	8.99 (d)	8.63 (m)	8.15 (m)	5.97, 6.00 (d, $J = 10.9$; $J = 10.7$)
4	I	9.52 (d)	8.79 (m)	8.30 (t)	6.29, 6.38 (d, $J = 10.2$; $J = 9.9$)
5	PF_6	8.82 (d)	8.56 (t)	8.07 (m)	5.84, 5.88 (d, $J = 10.2$; $J = 10.4$)
6a	NTf_2	8.96 (m)	8.61 (m)	8.13 (m)	5.90, 5.94 (d, $J = 10.4$)

[a] Shift in ppm and J in hertz.

Table 6. MIC and MBC values[a] of 1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]pyridinium chlorides **1**

Strain		Chlorides											
		1a	**1b**	**1c**	**1d**	**1e**	**1f**	**1g**	**1h**	**1i**	**1j**	**1k**	BAC[b]
M. luteus	MIC	14	27	27	27	26	5.9	198	>583	0.25	<0.25	<0.25	1.4
	MBC	14	54	27	27	51	12	198	>583	417	12	49	11
S. aureus	MIC	882	420	840	840	803	183	>584	1473	>1669	383	95	2.8
	MBC	>1764	1681	1681	>1681	>1605	736	>2348	1473	>1669	>5113	190	23
S. epidermidis	MIC	219	208	104	208	51	91	1595	368	1669	12	25	1.4
	MBC	1764	840	1681	1681	1605	1473	1595	1473	1669	25	49	5.6
E. faecium	MIC	1764	1681	1681	840	803	368	1595	>4698	>1669	383	383	5.6
	MBC	>1764	>1681	>1681	>1681	>1605	>1473	>4698	>13,837	>1669	766	1531	23
M. catarrhalis	MIC	882	208	420	208	199	183	1595	1473	1669	49	25	0.6
	MBC	882	840	420	420	401	183	>584	1473	1669	49	25	1.4
E. coli	MIC	219	208	104	208	100	24	399	368	1669	49	25	2.8
	MBC	219	208	208	840	401	47	797	736	1669	49	25	2.8
S. marcescens	MIC	>1764	>1681	>1681	>1681	>1605	>1473	>4698	>13,837	>1669	>5113	>15,661	175
	MBC	>1764	>1681	>1681	>1681	>1605	>1473	>4698	>13,837	>1669	>5113	>15,661	175
P. vulgaris	MIC	>1764	>1681	>1681	>1681	>1605	>1473	>4698	>13,837	>1669	>5113	>15,661	88
	MBC	>1764	>1681	>1681	>1681	>1605	>1473	>4698	>13,837	>1669	>5113	>15,661	88
P. aeruginosa	MIC	>1764	>1681	>1681	>1681	>1605	>1473	>4698	>13,837	>1669	>5113	>15,661	175
	MBC	>1764	>1681	>1681	>1681	>1605	>1473	>4698	>13,837	>1669	>5113	>15,661	175
B. subtilis	MIC	882	1681	208	1681	803	183	1595	>4698	>1669	383	383	2.8
	MBC	1764	1681	1681	>1681	1605	183	1595	>4698	>1669	383	383	2.8
C. albicans	MIC	>1764	>1681	>1681	>1681	>1605	1473	>4699	>13,840	1669	>5112	>15,656	11
	MBC	>1764	>1681	>1681	>1681	>1605	>1473	>4698	>13,837	1669	>5112	>15,656	88
R. rubra	MIC	>1764	>1681	>1681	1681	>1605	1473	>4699	>13,840	1669	1531	>4689	23
	MBC	>1764	>1681	>1681	1681	>1605	>1473	>4698	>13,837	1669	>5112	>15,656	88

[a] In μM.
[b] Benzalkonium chloride.

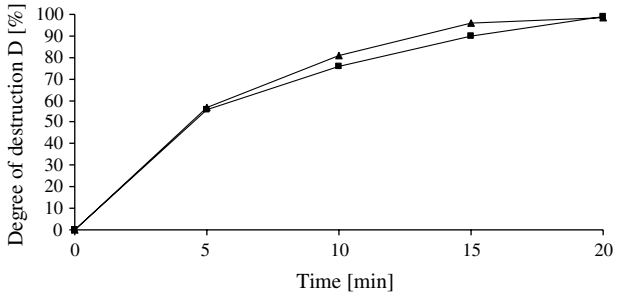


Figure 3. Decay of **1i** (■) and **1k** (▲) in the presence of ozone as a function of time.

satisfactory microanalysis was obtained (C ±0.37, H ±0.36, and N ±0.24). Optical rotations were measured with a Perkin–Elmer 243 B polarimeter.

Melting points were determined using a model JA 9100 electrothermal digital melting-point apparatus. A Metter Toledo DA 110 M scale was used for the mass/density measurements.

Water content was determined using a volumetric Aquastar Karl Fischer titrator with Composite 5 solution as the titrant and anhydrous methanol as the solvent.

3-(Dimethylamino)pyridine was obtained according to the procedure described earlier.[11] Chloromethyl (1*R*,2*S*,5*R*)-(−)-menthyl ether was prepared by passing HCl through a mixture of formaldehyde and (1*R*,2*S*,5*R*)-(−)-menthol.[4,12]

4.1. Menschutkin quaternization

A three-necked, round-bottomed flask equipped with a magnetic stirring bar, reflux condenser, and dropping funnel was charged with pyridine derivatives dried by azeotropic distillation with chloroform and 30 mL of freshly distilled solvent (hexane for **1a**–**f** and **1k**; DMF for **1g**–**j**). Chloromethyl (1*R*,2*S*,5*R*)-(−)-menthyl ether with a boiling point of 108 °C at 16 mm Hg was added dropwise. The resulting mixture was vigorously stirred at room temperature. The suspension was filtered, washed with diethyl ether, and recrystallized.

4.2. Metathesis reaction

4.2.1. Preparation of solid salts. A saturated aqueous solution of $NaBF_4$, $NaClO_4$, KI, KPF_6, or Tf_2NLi was added to a stoichiometric amount of aqueous solution of prepared pyridinium chloride **1**. The reaction mixture was stirred at room temperature for 24 h. The precipitated solid was filtered off and washed with water. The crude material was recrystallized.

4.2.2. Preparation of liquid salts. A saturated aqueous solution of Tf_2NLi was added to a stoichiometric amount of aqueous solution of prepared pyridinium chloride **1**. The reaction mixture was stirred at room temperature for 24 h. After separation of the phases, the organic phase was washed with distilled water until chloride ions were no longer detected using $AgNO_3$. The obtained liquid was dried for 12 h at 80 °C in a vacuum.

4.2.3. Anti-microbial activity. The following microorganisms were used: *Micrococcus luteus* NCTC 7743, *Staphylococcus aureus* NCTC 4163, *Staphylococcus epidermidis* ATCC 49134, *Enterococcus faecium* ATCC 49474, *Moraxella catarrhalis* ATCC 25238, *Escherichia coli* ATCC 25922, *Serratia marcescens* ATCC 8100, *Proteus vulgaris* MCTC 4635, *Pseudomonas aeruginosa* NCTC 6749, *Bacillus subtilis* ATCC 6633, *Candida albicans* NCTS 4163, and *Rhodothorula rubra* (Demml 1889, Lodder 1934). Standard strains were supplied by the National Collection of Type Cultures (NCTC) London, and American Type Culture Collection (ATCC). *Rhodothorula rubra* was obtained from the Department of Pharmaceutical Bacteriology, University of Medical Sciences, Poznań.

Anti-microbial activity was determined by the tube dilution method. A series of chiral pyridinium chlorides dilutions were prepared in Müller–Hinton broth medium (bacteria) or Sabouraud broth medium (fungi). Bacteria strains were cultured in a Müller–Hinton broth for 24 h and fungi on Sabouraud agar for 48 h. Suspensions of the microorganisms, at the concentration of 10^6 cfu cm^{-3} (cfu = colony forming units), were prepared from each culture. Then, to each dilution of the tested agent in the broth medium the above-mentioned microbe suspension was inoculated, at a 1:1 ratio. Growth (or lack thereof) of the microorganisms was determined visually after incubation for 24 h at 37 °C (bacteria) or 48 h at 28–30 °C (fungi). The lowest concentration at which there was no visible growth (turbidity) was taken as the MIC. Then, from each tube, one loopful was cultured in an agar medium with inactivates (0.3% lecithin, 3% polysorbate 80% and 0.1% cysteine L) and incubated for 48 h at 37 °C (bacteria) or for 5 d at 28–30 °C (fungi). The lowest concentration of chiral pyridinium salt supporting no colony formation was defined as the MBC.

4.3. Ozonation

The measuring apparatus, the method of measurement, and the measurement conditions were described by Pernak et al.[10] An aqueous ozone solution of approximately 5 mg/L and of pH 4.2 was prepared by bubbling ozone-oxygen gas through a 2 g/L aqueous solution of a tested chloride. The reaction mixture was determined by a direct two-phase back titration, according to the EN ISO 2871-1 (2000) standard.

4.3.1. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]pyridinium chloride 1a. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.43$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.89 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.31 (m, 1H, H2), 1.43 (m, 1H, H5), 1.62 (m, 2H, Hb-3 and Hb-4), 1.96 (sept d, $J = 6.9$, 4.4 Hz, 1H, H8), 2.14 (d, $J = 11.8$ Hz, 1H, Hb-6), 3.54 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 6.38 and 6.51 (d, $J = 10.2$ Hz, 2H, AB system, H11), 8.33 (t, $J = 7.4$, 6.6 Hz, 2H, H13 and H15), 8.81 (t, $J = 7.7$ Hz, 1H, H14), 9.75 (d, $J = 5.5$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 14.8$ (C9 or C10), 20.1 (C7), 21.3 (C9 or C10), 21.8 (C3), 24.6 (C8), 30.3 (C5), 33.0 (C4), 39.7 (C6), 46.7 (C2), 80.3 (C1), 86.3 (C11), 127.3 (C13 and C15), 142.9 (C14), 146.1 (C12 and C16). Elemental analysis calcd (%) for $C_{16}H_{26}ClNO$ (283.88): C 67.69, H 9.25, N 4.93. Found: C 67.85, H 9.17, N 4.88.

4.3.2. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-2-methylpyridinium chloride 1b. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.36$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.88 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.25 (m, 1H, H2), 1.46 (m, 1H, H5), 1.62 (m, 2H, Hb-3 and Hb-4), 1.78 (sept d, $J = 6.9$, 4.4 Hz, 1H, H8), 2.18 (m, 1H, Hb-6), 3.06 (s, 3H, CH_3–R^1), 3.54 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 6.30 and 6.50 (d, $J = 10.7$ Hz, 2H, AB system, H11), 7.97 (m, 2H, H15 and H13), 8.46 (m, 1H, H14), 10.04 (m, 1H, H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.3$ (C9 or C10), 20.1 (C7), 20.8 (CH_3–R^1), 22.0 (C9 or C10), 22.6 (C3), 25.6 (C8), 31.1 (C5), 33.9 (C4), 40.5 (C6), 47.6 (C2), 80.7 (C1), 86.0 (C11), 125.6 (C15), 129.9 (C13), 146.2 (C14), 147.0 (C16), 155.5 (C12). Elemental analysis calcd (%) for $C_{17}H_{28}ClNO$ (297.91): C 68.53, H 9.49, N 4.70. Found: C 68.33, H 9.55, N 4.80.

4.3.3. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-3-methylpyridinium chloride 1c. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.46$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.90 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.37 (m, 2H, H2 and H5), 1.63 (m, 2H, Hb-3 and Hb-4), 1.98 (sept d, $J = 7.1$, 4.7 Hz, 1H, H8), 2.16 (m, 1H, Hb-6), 2.68 (s, 3H, CH_3–R^2), 3.50 (td, $J = 10.7$, 4.4 Hz, 1H, H1), 6.26 and 6.45 (d, $J = 10.2$ Hz, 2H, AB system, H11), 8.11 (m, 1H, H15), 8.40 (d, $J = 7.7$ Hz, 1H, H14), 9.44 (d, $J = 6.0$ Hz, 1H, H16), 9.51 (s, 1H, H12); ^{13}C NMR ($CDCl_3$): $\delta = 15.4$ (C9 or C10), 18.6 (CH_3–R^2), 20.8 (C7), 21.9 (C9 or C10), 22.6 (C3), 25.4 (C8), 31.0 (C5), 33.8 (C4), 40.4 (C6), 47.6 (C2), 81.2 (C1), 87.0 (C11), 127.4 (C15), 139.2 (C13), 140.9 (C14), 143.0 (C16), 146.9 (C12). Elemental analysis calcd (%) for $C_{17}H_{28}ClNO$ (297.91): C 68.53, H 9.49, N 4.70. Found: C 68.45, H 9.52, N 4.59.

4.3.4. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-4-methylpyridinium chloride 1d. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.47$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.89 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.37 (m, 2H, H2 and H5), 1.62 (m, 2H, Hb-3 and Hb-4), 1.97 (sept d, $J = 6.9$, 4.4 Hz, 1H, H8), 2.13 (m, 1H, Hb-6), 2.73 (s, 3H, CH_3–R^3), 3.50 (td, $J = 10.7$, 4.4 Hz, 1H, H1), 6.23 and 6.40 (d, $J = 10.2$, 10.4 Hz, 2H, AB system, H11), 8.73 (d, $J = 6.6$ Hz, 2H, H13 and H15), 9.48 (d, $J = 6.9$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.5$ (C9 or C10), 20.8 (C7), 21.9 (C9 or C10), 22.3 (CH_3–R^3), 22.6 (C3), 25.4 (C8), 31.0 (C5), 33.8 (C4), 40.4 (C6), 47.6 (C2), 81.2 (C1), 86.6 (C11), 128.4 (C13 and C15), 142.9 (C14), 160.3 (C12 and C16). Elemental analysis calcd (%) for $C_{17}H_{28}ClNO$ (297.91): C 68.53, H 9.49, N 4.70. Found: C 68.38, H 9.53, N 4.77.

4.3.5. 4-Ethyl-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]pyridinium chloride 1e. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.44$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.87 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.36 (m, 5H, H2, H5 and CH_3–R^3), 1.62 (m, 2H, Hb-3 and Hb-4), 1.95 (sept d, $J = 7.1$, 4.4 Hz, 1H, H8), 2.14 (m, 1H, Hb-6), 3.01 (q, $J = 7.7$ Hz, 2H, CH_2–R^3), 3.50 (td, $J = 10.7$, 4.4 Hz, 1H, H1), 6.24 and 6.39 (d, $J = 10.2$ Hz, 2H, AB system, H11), 7.99 (d, $J = 6.6$ Hz, 2H, H13 and H15), 9.55 (d, $J = 6.6$ Hz, 2H,

H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 13.3$ (CH_3–R^3), 15.4 (C9 or C10), 20.8 (C7), 21.9 (C9 or C10), 22.6 (C3), 25.4 (C8), 29.0 (CH_2–R^3), 31.0 (C5), 33.8 (C4), 40.4 (C6), 47.5 (C2), 80.8 (C1), 86.3 (C11), 126.9 (C13 and C15), 142.9 (C12 and C16), 165.4 (C14). Elemental analysis calcd (%) for $C_{18}H_{30}ClNO$ (311.94): C 69.30, H 9.71, N 4.49. Found: C 69.18, H 9.79, N 4.56.

4.3.6. 4-*tert*-Butyl-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]pyridinium chloride 1f. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.36$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.93 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.39 (m, 13H, H2, CH_3–R^3, H5, Hb-3 and Hb-4), 1.93 (sept d, $J = 6.9$, 4.7 Hz, 1H, H8), 2.24 (m, 1H, Hb-6), 3.52 (td, $J = 10.7$, 4.4 Hz, 1H, H1), 6.32 and 6.43 (d, $J = 9.9$, 10.2 Hz, 2H, AB system, H11), 8.17 (d, $J = 6.9$ Hz, 2H, H13 and H15), 9.80 (d, $J = 6.9$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 20.1$ (C9 or C10), 20.3 (C7), 21.3 (C9 or C10), 21.8 (C3), 24.5 (C8), 29.2 (CH_3–R^3), 30.2 (C5), 33.1 (C4), 35.9 (C–R^3), 39.6 (C6), 46.6 (C2), 79.6 (C1), 85.3 (C11), 124.2 (C13 and C15), 143.0 (C12 and C16), 171.5 (C14). Elemental analysis calcd (%) for $C_{20}H_{34}ClNO$ (340.00): C 70.65, H 10.10, N 4.12. Found: C 70.73, H 9.98, N 4.07.

4.3.7. 5-Hydroxy-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]-2-methylpyridinium chloride 1g. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.42$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.91 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.27 (m, 1H, H2), 1.43 (m, 1H, H5), 1.64 (m, 2H, Hb-3 and Hb-4), 1.83 (sept d, $J = 6.9$, 4.2 Hz, 1H, H8), 2.38 (m, 1H, Hb-6), 2.84 (s, 3H, CH_3–R^1), 3.42 (td, $J = 10.5$, 4.2 Hz, 1H, H1), 5.88 and 5.93 (d, $J = 10.8$, 10.5 Hz, 2H, AB system, H11), 7.50 (d, $J = 8.7$ Hz, 1H, H13), 8.14 (m, 1H, H14), 8.97 (m, 1H, H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.5$ (C9 or C10), 18.9 (CH_3–R^1), 21.0 (C7), 22.1 (C9 or C10), 22.7 (C3), 25.7 (C8), 31.3 (C5), 34.0 (C4), 40.3 (C6), 47.7 (C2), 80.7 (C1), 86.2 (C11), 129.8 (C14), 133.1 (C13), 134.2 (C16), 143.9 (C15), 156.4 (C12). Elemental analysis calcd (%) for $C_{17}H_{28}ClNO_2$ (313.91): C 65.04, H 9.01, N 4.46. Found: C 64.89, H 9.13, N 4.52.

4.3.8. 3-Carbamoyl-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]-pyridinium chloride 1h. ^{1}H NMR (DMSO-d_6, 25 °C): $\delta = 0.27$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.82 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.21 (m, 1H, H2), 1.43 (m, 1H, H5), 1.57 (m, 2H, Hb-3 and Hb-4), 1.87 (sept d, $J = 6.0$, 4.0 Hz, 1H, H8), 2.10 (d, $J = 11.7$ Hz, 1H, Hb-6), 3.45 (td, $J = 10.5$, 4.0 Hz, 1H, H1), 6.06 and 6.12 (d, $J = 10.1$ Hz, 2H, AB system, H11), 8.26 (s, 1H, NH_2), 8.37 (m, 1H, H15), 9.09 (s, 1H, NH_2), 9.24 (d, $J = 8.5$ Hz, 1H, H14), 9.44 (d, $J = 6.1$ Hz, 1H, H16), 9.94 (s, 1H, H12); ^{13}C NMR (DMSO-d_6): $\delta = 15.1$ (C9 or C10), 20.9 (C7), 22.0 (C9 or C10), 22.2 (C3), 24.8 (C8), 30.6 (C5), 33.5 (C4), 40.3 (C6), 47.1 (C2), 79.0 (C1), 86.7 (C11), 127.9 (C15), 133.4 (C13), 144.2 (C14), 145.2 (C16), 145.5 (C12), 162.5 ($CONH_2$). Elemental analysis calcd (%) for $C_{17}H_{27}ClN_2O_2$ (326.91): C 62.45, H 8.34, N 8.57. Found: C 62.56, H 8.28, N 8.50.

4.3.9. 3-Hydroxy-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]pyridinium chloride 1i. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.51$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.80 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.30 (m, 2H, H2 and H5), 1.66 (m, 2H, Hb-3 and Hb-4), 2.00 (m, 2H, H8 and Hb-6), 3.41 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.86 and 5.92 (d, $J = 9.9$, 10.2 Hz, 2H, AB system, H11), 7.76 (m, 1H, H15), 8.21 (m, 2H, H14 and H16), 9.16 (s, 1H, H12); ^{13}C NMR ($CDCl_3$): $\delta = 15.5$ (C9 or C10), 20.8 (C7), 22.0 (C9 or C10), 22.6 (C3), 25.5 (C8), 31.3 (C5), 33.8 (C4), 40.3 (C6), 47.6 (C2), 81.9 (C1), 87.7 (C11), 127.8 (C14), 130.9 (C15), 131.7 (C12), 133.8 (C16), 159.0 (C13). Elemental analysis calcd (%) for $C_{16}H_{26}ClNO_2$ (299.88): C 64.08, H 8.76, N 4.67. Found: C 64.19, H 8.70, N 4.69.

4.3.10. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-4-(dimethylamino)pyridinium chloride 1j. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.50$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 1.00 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.25 (m, 1H, H2), 1.40 (m, 1H, H5), 1.62 (m, 2H, Hb-3 and Hb-4), 2.03 (m, 2H, H8 and Hb-6), 3.32 (m, 7H, $N(CH_3)_2$ and H1), 5.63 and 5.77 (d, $J = 10.4$ Hz, 2H, AB system, H11), 7.06 (d, $J = 8.0$ Hz 2H, H13 and H15), 8.58 (d, $J = 7.7$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.7$ (C9 or C10), 21.0 (C7), 22.1 (C9 or C10), 22.8 (C3), 25.4 (C8), 31.2 (C5), 34.0 (C4), 40.3 (C6), 40.6 ($N(CH_3)_2$), 47.7 (C2), 79.5 (C1), 83.9 (C11), 107.7 (C13 and C15), 141.4 (C12 and C16), 156.8 (C14). Elemental analysis calcd (%) for $C_{18}H_{31}ClN_2O$ (326.96): C 66.12, H 9.58, N 8.57. Found: C 66.01, H 9.63, N 8.54.

4.3.11. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-3-(dimethylamino)pyridinium chloride 1k. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.50$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.90 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.29 (m, 1H, H2), 1.42 (m, 1H, H5), 1.62 (m, 2H, Hb-3 and Hb-4), 2.01 (sept d, $J = 6.6$, 4.1 Hz, 1H, H8), 2.22 (d, $J = 11.8$ Hz, 1H, Hb-6), 3.24 (s, 6H, $N(CH_3)_2$), 3.53 (td, $J = 10.7$, 4.4 Hz, 1H, H1), 6.14 and 6.44 (d, $J = 10.2$, 10.4 Hz, 2H, AB system, H11), 7.69 (m, 1H, H15), 7.82 (m, 1H, H14), 8.35 (d, $J = 5.8$ Hz, 1H, H16), 9.32 (m, 1H, H12); ^{13}C NMR ($CDCl_3$): $\delta = 15.4$ (C9 or C10), 20.7 (C7), 21.9 (C9 or C10), 22.4 (C3), 25.4 (C8), 30.9 (C5), 33.7 (C4), 40.2 ($N(CH_3)_2$), 40.3 (C6), 47.5 (C2), 80.9 (C1), 86.8 (C11), 125.1 (C15), 127.1 (C14), 127.2 (C16), 127.4 (C12), 148.0 (C13). Elemental analysis calcd (%) for $C_{18}H_{31}ClN_2O$ (326.96): C 66.12, H 9.58, N 8.57. Found: C 66.18, H 9.62, N 8.46.

4.3.12. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]pyridinium tetrafluoroborate 2a. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.43$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.89 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.35 (m, 2H, H2 and H5), 1.62 (m, 2H, Hb-3 and Hb-4), 1.96 (m, 2H, H8 and Hb-6), 3.41 (td, $J = 10.7$, 4.4 Hz, 1H, H1), 5.92 and 5.96 (d, $J = 10.9$, 10.7 Hz, 2H, AB system, H11), 8.11 (t, $J = 7.4$, 6.9 Hz, 2H, H13 and H15), 8.60 (t, $J = 7.7$ Hz, 1H, H14), 8.94 (d, $J = 5.8$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.3$ (C9 or C10), 20.8 (C7), 22.0 (C9 or C10), 22.6 (C3), 25.4 (C8), 31.0 (C5), 33.8 (C4), 40.1 (C6), 47.5 (C2), 81.2 (C1), 87.6 (C11), 128.1 (C13 and C15), 142.7 (C14), 147.0 (C12 and C16). Elemental analysis calcd (%) for $C_{16}H_{26}BF_4NO$ (335.23): C 57.32, H 7.83, N 4.18. Found: C 57.45, H 7.78, N 4.11.

4.3.13. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-2-methylpyridinium tetrafluoroborate 2b. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.35$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.87 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.26 (m, 1H, H2), 1.46 (m, 1H, H5), 1.61 (m, 2H, Hb-3 and Hb-4), 1.78 (m, 2H, H8 and Hb-6), 2.98 (s, 3H, CH_3–R^1), 3.43 (td, $J = 10.4$ Hz, $J = 4.1$ Hz, 1H, H1), 5.87 and 5.99 (d, $J = 10.4$ Hz, 2H, AB system, H11), 7.86 (m, 2H, H15 and H13), 8.41 (m, 1H, H14), 9.34 (m, 1H, H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.1$ (C9 or C10), 19.8 (C7), 20.5 (CH_3–R^1), 21.9 (C9 or C10), 22.3 (C3), 25.2 (C8), 30.9 (C5), 33.6 (C4), 39.9 (C6), 47.3 (C2), 80.3 (C1), 86.1 (C11), 125.5 (C15), 130.1 (C13), 145.8 (C14), 146.2 (C16), 154.9 (C12). Elemental analysis calcd (%) for $C_{17}H_{28}BF_4NO$ (349.26): C 58.46, H 8.10, N 4.01. Found: C 58.38, H 8.18, N 4.09.

4.3.14. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-3-methylpyridinium tetrafluoroborate 2c. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.44$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.89 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.37 (m, 2H, H2 and H5), 1.62 (m, 2H, Hb-3 and Hb-4), 1.98 (m, 2H, H8 and Hb-6), 2.61 (s, 3H, CH_3–R^2), 3.40 (td, $J = 10.7$, 4.4 Hz, 1H, H1), 5.89 and 5.93 (d, $J = 10.4$, 10.2 Hz, 2H, AB system, H11), 8.01 (m, 1H, H15), 8.41 (d, $J = 8.0$ Hz, 1H, H14), 8.78 (m, 2H, H16 and H12); ^{13}C NMR ($CDCl_3$): $\delta = 15.0$ (C9 or C10), 18.1 (CH_3–R^2), 20.7 (C7), 21.7 (C9 or C10), 22.3 (C3), 25.1 (C8), 30.8 (C5), 33.6 (C4), 39.8 (C6), 47.3 (C2), 80.8 (C1), 87.1 (C11), 127.4 (C15), 139.5 (C13), 139.9 (C14), 142.3 (C16), 147.3 (C12). Elemental analysis calcd (%) for $C_{17}H_{28}BF_4NO$ (349.26): C 58.46, H 8.10, N 4.01. Found: C 58.57, H 8.13, N 3.89.

4.3.15. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-4-methylpyridinium tetrafluoroborate 2d. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.45$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.88 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.34 (m, 2H, H2 and H5), 1.61 (m, 2H, Hb-3 and Hb-4), 1.99 (m, 2H, H8 and Hb-6), 2.70 (s, 3H, CH_3–R^3), 3.39 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.80 and 5.89 (d, $J = 10.4$ Hz, 2H, AB system, H11), 8.65 (d, $J = 6.7$ Hz, 2H, H13 and H15), 8.82 (d, $J = 6.9$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.2$ (C9 or C10), 20.7 (C7), 21.7 (C9 or C10), 22.1 (CH_3–R^3), 22.3 (C3), 25.2 (C8), 30.8 (C5), 33.6 (C4), 39.9 (C6), 47.3 (C2), 80.8 (C1), 86.7 (C11), 128.3 (C13 and C15), 141.8 (C14), 159.6 (C12 and C16). Elemental analysis calcd (%) for $C_{17}H_{28}BF_4NO$ (349.26): C 58.46, H 8.10, N 4.01. Found: C 58.41, H 8.21, N 4.13.

4.3.16. 4-Ethyl-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]pyridinium tetrafluoroborate 2e. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.43$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.88 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.35 (m, 5H, H2, H5 and CH_3–R^3), 1.62 (m, 2H, Hb-3 and Hb-4), 1.96 (m, 2H, H8 and Hb-6), 2.99 (q, $J = 7.7$ Hz, 2H, CH_2–R^3), 3.39 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.80 and 5.86 (d, $J = 10.4$ Hz, 2H, AB system, H11), 7.95 (d, $J = 6.6$ Hz, 2H, H13 and H15), 8.95 (d, $J = 6.6$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 13.1$ (CH_3–R^3), 15.3 (C9 or C10), 20.7 (C7), 21.7 (C9 or C10), 22.4 (C3), 25.3 (C8), 28.8 (CH_2–R^3), 30.8 (C5), 33.6 (C4), 39.8 (C6), 47.4 (C2), 80.4 (C1), 85.9 (C11), 126.2 (C13 and C15), 141.0 (C12 and C16), 164.9 (C14). Elemental analysis calcd (%) for $C_{18}H_{30}BF_4NO$ (363.29): C 59.51, H 8.34, N 3.86. Found: C 59.63, H 8.26, N 3.81.

4.3.17. 5-Hydroxy-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]-2-methylpyridinium tetrafluoroborate 2f. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.43$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.89 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.33 (m, 2H, H2 and H5), 1.62 (m, 2H, Hb-3 and Hb-4), 1.92 (m, 2H, H8 and Hb-6), 2.79 (s, 3H, CH_3–R^1), 3.31 (td, $J = 10.5$, 4.2 Hz, 1H, H1), 5.44 and 5.49 (d, $J = 10.4$ Hz, 2H, AB system, H11), 7.45 (d, $J = 8.7$ Hz, 1H, H13), 8.08 (m, 1H, H14), 8.35 (m, 1H, H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.3$ (C9 or C10), 18.8 (CH_3–R^1), 20.8 (C7), 21.8 (C9 or C10), 22.5 (C3), 25.4 (C8), 31.1 (C5), 33.8 (C4), 39.8 (C6), 47.3 (C2), 80.1 (C1), 87.0 (C11), 129.7 (C14), 132.8 (C13), 133.5 (C16), 142.7 (C15), 155.8 (C12). Elemental analysis calcd (%) for $C_{17}H_{28}BF_4NO_2$ (365.26): C 55.90, H 7.74, N 3.83. Found: C 55.98, H 7.68, N 3.79.

4.3.18. 3-Carbamoyl-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]-pyridinium tetrafluoroborate 2g. ^{1}H NMR (DMSO-d_6, 25 °C): $\delta = 0.30$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.90 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.36 (m, 2H, H2 and H5), 1.58 (m, 2H, Hb-3 and Hb-4), 1.92 (sept d, $J = 6.9$, 4.9 Hz, 1H, H8), 2.09 (d, $J = 11.8$ Hz, 1H, Hb-6), 3.43 (td, $J = 10.4$, 3.8 Hz, 1H, H1), 6.04 and 6.09 (d, $J = 10.2$ Hz, 2H, AB system, H11), 8.20 (s, 1H, NH_2), 8.37 (m, 1H, H15), 8.64 (s, 1H, NH_2), 9.08 (d, $J = 8.2$ Hz, 1H, H14), 9.34 (d, $J = 6.0$ Hz, 1H, H16), 9.66 (s, 1H, H12); ^{13}C NMR (DMSO-d_6): $\delta = 15.2$ (C9 or C10), 20.8 (C7), 22.0 (C9 or C10), 22.4 (C3), 24.9 (C8), 30.7 (C5), 33.6 (C4), 40.1 (C6), 47.2 (C2), 79.5 (C1), 86.1 (C11), 128.0 (C15), 133.8 (C13), 143.8 (C14), 145.1 (C16), 145.5 (C12), 162.7 ($CONH_2$). Elemental analysis calcd (%) for $C_{17}H_{27}BF_4N_2O_2$ (378.26): C 53.98, H 7.21, N 7.41. Found: C 53.91, H 7.29, N 7.50.

4.3.19. 3-Hydroxy-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]pyridinium tetrafluoroborate 2h. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.48$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.90 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.36 (m, 2H, H2 and H5), 1.62 (m, 2H, Hb-3 and Hb-4), 1.99 (m, 2H, H8 and Hb-6), 3.38 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.80 (m, 2H, AB system, H11), 7.85 (m, 1H, H15), 8.06 (m, 1H, H14), 8.38 (d, $J = 6.0$ Hz, 1H, H16), 8.50 (s, 1H, H12); ^{13}C NMR ($CDCl_3$): $\delta = 15.3$ (C9 or C10), 20.8 (C7), 21.9 (C9 or C10), 22.6 (C3), 25.4 (C8), 31.1 (C5), 33.8 (C4), 40.0 (C6), 47.6 (C2), 81.4 (C1), 87.7 (C11), 128.4 (C14), 130.9 (C15), 133.4 (C12), 133.7 (C16), 157.1 (C13). Elemental analysis calcd (%) for $C_{16}H_{26}BF_4NO_2$ (351.23): C 54.71, H 7.48, N 3.99. Found: C 54.59, H 7.56, N 4.09.

4.3.20. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-4-(dimethylamino)pyridinium tetrafluoroborate 2i. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.50$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.89 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.24 (m, 1H, H2), 1.40 (m, 1H, H5), 1.61 (m, 2H, Hb-3 and Hb-4), 1.99 (m, 2H, H8 and Hb-6), 3.28 (m, 7H, $N(CH_3)_2$ and H1), 5.44 and 5.48 (d, $J = 10.4$ Hz, 2H, AB system, H11), 6.94 (d, $J = 7.7$ Hz, 2H, H13 and H15), 8.15 (d, $J = 8.0$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.4$ (C9 or C10), 20.8 (C7), 21.9 (C9 or C10), 22.6

(C3), 25.2 (C8), 31.0 (C5), 33.9 (C4), 40.0 (C6), 40.2 ($N(CH_3)_2$), 47.6 (C2), 79.3 (C1), 83.9 (C11), 107.6 (C13 and C15), 140.9 (C12 and C16), 156.9 (C14). Elemental analysis calcd (%) for $C_{18}H_{31}BF_4N_2O$ (378.31): C 57.14, H 8.28, N 7.41. Found: C 57.29, H 8.21, N 7.45.

4.3.21. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-3-(dimethylamino)pyridinium tetrafluoroborate 2j. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.48$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.90 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.34 (m, 2H, H2 and H5), 1.62 (m, 2H, Hb-3 and Hb-4), 2.02 (m, 2H, H8 and Hb-6), 3.15 (s, 6H, $N(CH_3)_2$), 3.40 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.81 and 5.86 (d, $J = 10.2$ Hz, 2H, AB system, H11), 7.68 (m, 1H, H15), 7.77 (m, 1H, H14), 8.12 (m, 2H, H16 and H12); ^{13}C NMR ($CDCl_3$): $\delta = 15.3$ (C9 or C10), 20.7 (C7), 21.8 (C9 or C10), 22.5 (C3), 25.3 (C8), 30.9 (C5), 33.7 (C4), 39.6 ($N(CH_3)_2$), 39.9 (C6), 47.4 (C2), 81.0 (C1), 87.4 (C11), 124.7 (C15), 126.3 (C14), 127.4 (C16), 127.8 (C12), 148.2 (C13). Elemental analysis calcd (%) for $C_{18}H_{31}BF_4N_2O$ (378.31): C 57.14, H 8.28, N 7.41. Found: C 57.25, H 8.19, N 7.42.

4.3.22. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]pyridinium perchlorate 3. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.44$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.90 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.36 (m, 2H, H2 and H5), 1.62 (m, 2H, Hb-3 and Hb-4), 1.98 (m, 2H, H8 and Hb-6), 3.44 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.97 and 6.00 (d, $J = 10.9$, 10.7 Hz, 2H, AB system, H11), 8.15 (m, 2H, H13 and H15), 8.63 (m, 1H, H14), 8.99 (d, $J = 5.5$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.4$ (C9 or C10), 20.9 (C7), 22.0 (C9 or C10), 22.6 (C3), 25.4 (C8), 31.0 (C5), 33.8 (C4), 40.1 (C6), 47.5 (C2), 81.4 (C1), 87.6 (C11), 128.2 (C13 and C15), 142.8 (C14), 147.0 (C12 and C16). Elemental analysis calcd (%) for $C_{16}H_{26}ClNO_5$ (347.88): C 55.24, H 7.55, N 4.03. Found: C 55.39, H 7.40, N 3.97.

4.3.23. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]pyridinium iodide 4. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.47$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.89 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.33 (m, 1H, H2), 1.47 (m, 1H, H5), 1.63 (m, 2H, Hb-3 and Hb-4), 1.98 (sept d, $J = 6.9$, 4.4 Hz, 1H, H8), 2.16 (m, 1H, Hb-6), 3.57 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 6.29 and 6.38 (d, $J = 10.2$, 9.9 Hz, 2H, AB system, H11), 8.30 (t, $J = 7.7$, 6.6 Hz, 2H, H13 and H15), 8.79 (m, 1H, H14), 9.52 (d, $J = 5.5$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.4$ (C9 or C10), 20.6 (C7), 21.8 (C9 or C10), 22.3 (C3), 25.2 (C8), 30.7 (C5), 33.5 (C4), 40.2 (C6), 47.2 (C2), 81.0 (C1), 86.8 (C11), 127.9 (C13 and C15), 142.8 (C14), 146.8 (C12 and C16). Elemental analysis calcd (%) for $C_{16}H_{26}INO$ (375.33): C 51.20, H 7.00, N 3.73. Found: C 51.36, H 6.88, N 3.68.

4.3.24. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]pyridinium hexafluorophosphate 5. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.43$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.86 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.34 (m, 2H, H2 and H5), 1.60 (m, 2H, Hb-3 and Hb-4), 1.97 (m, 2H, H8 and Hb-6), 3.38 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.84 and 5.88 (d, $J = 10.2$, 10.4 Hz, 2H, AB system, H11), 8.07 (m, 2H, H13 and H15), 8.56 (t, $J = 7.7$ Hz, 1H, H14), 8.82 (d, $J = 5.5$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.3$ (C9 or C10), 20.9 (C7), 22.0 (C9 or C10), 22.7 (C3), 25.4 (C8), 31.0 (C5), 33.9 (C4), 40.1 (C6), 47.6 (C2), 81.4 (C1), 87.6 (C11), 128.2 (C13 and C15), 142.4 (C14), 147.1 (C12 and C16). Elemental analysis calcd (%) for $C_{16}H_{26}F_6NOP$ (393.40): C 48.85, H 6.67, N 3.56. Found: C 48.99, H 6.57, N 3.49.

4.3.25. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]pyridinium bis(trifluoromethanesulfonyl)imide 6a. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.46$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.83 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.38 (m, 2H, H2 and H5), 1.64 (m, 2H, Hb-3 and Hb-4), 2.05 (m, 2H, H8 and Hb-6), 3.42 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.90 and 5.94 (d, $J = 10.4$ Hz, 2H, AB system, H11), 8.13 (m, 2H, H13 and H15), 8.61 (m, 1H, H14), 8.96 (m, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.0$ (C9 or C10), 20.6 (C7), 21.6 (C9 or C10), 22.4 (C3), 25.2 (C8), 30.9 (C5), 33.6 (C4), 39.9 (C6), 47.4 (C2), 81.6 (C1), 87.5 (C11), 128.2 (C13 and C15), 146.9 (C14), 147.0 (C12 and C16); anion: 113.2, 117.4, 121.7, 125.9. Elemental analysis calcd (%) for $C_{18}H_{26}F_6N_2O_5S_2$ (528.66): C 40.89, H 4.97, N 5.30. Found: C 40.97, H 4.80, N 5.19.

4.3.26. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-2-methylpyridinium bis(trifluoromethanesulfonyl)imide 6b. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.40$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.83 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.30 (m, 2H, H2 and H5), 1.64 (m, 2H, Hb-3 and Hb-4), 2.03 (m, 2H, H8 and Hb-6), 3.02 (s, 3H, CH_3–R^1), 3.42 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.90 and 5.94 (d, $J = 10.7$ Hz, 2H, AB system, H11), 7.82 (m, 2H, H15 and H13), 8.28 (m, 1H, H14), 9.34 (m, 1H, H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.1$ (C9 or C10), 20.6 (C7), 20.7 (CH_3–R^1), 21.8 (C9 or C10), 22.4 (C3), 25.2 (C8), 30.9 (C5), 33.6 (C4), 40.1 (C6), 47.4 (C2), 79.2 (C1), 85.1 (C11), 124.2 (C15), 128.9 (C13), 145.6 (C14), 146.2 (C16), 154.4 (C12); anion: 113.3, 117.5, 121.8, 126.0. Elemental analysis calcd (%) for $C_{19}H_{28}F_6N_2O_5S_2$ (542.69): C 42.05, H 5.21, N 5.16. Found: C 42.17, H 5.19, N 5.23.

4.3.27. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-3-methylpyridinium bis(trifluoromethanesulfonyl)imide 6c. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.41$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.89 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.35 (m, 2H, H2 and H5), 1.64 (m, 2H, Hb-3 and Hb-4), 2.05 (m, 2H, H8 and Hb-6), 2.67 (s, 3H, CH_3–R^2), 3.35 (td, $J = 10.7$, 4.4 Hz, 1H, H1), 5.84 and 5.90 (d, $J = 10.2$ Hz, 2H, AB system, H11), 8.01 (m, 1H, H15), 8.20 (d, $J = 7.7$ Hz, 1H, H14), 9.30 (d, $J = 6.1$ Hz, 1H, H16), 9.36 (s, 1H, H12); ^{13}C NMR ($CDCl_3$): $\delta = 15.3$ (C9 or C10), 18.5 (CH_3–R^2), 20.6 (C7), 21.7 (C9 or C10), 22.4 (C3), 25.1 (C8), 30.8 (C5), 33.6 (C4), 39.9 (C6), 47.4 (C2), 80.1 (C1), 85.8 (C11), 126.6 (C15), 138.6 (C13), 140.1 (C14), 141.7 (C16), 145.1 (C12); anion: 113.2, 117.4, 121.9, 126.0. Elemental analysis calcd (%) for $C_{19}H_{28}F_6N_2O_5S_2$ (542.69): C 42.05; H 5.21; N 5.16. Found: C 41.97; H 5.29; N 5.22.

4.3.28. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-4-methylpyridinium bis(trifluoromethanesulfonyl)imide 6d. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.46$ (d, $J = 6.9$ Hz, 3H, H9 or H10),

0.88 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.35 (m, 2H, H2 and H5), 1.63 (m, 2H, Hb-3 and Hb-4), 2.05 (m, 2H, H8 and Hb-6), 2.70 (s, 3H, CH_3–R^3), 3.36 (td, $J = 10.7$ Hz, $J = 4.4$ Hz, 1H, H1), 5.77 and 5.81 (d, $J = 10.4$ Hz, 2H, AB system, H11), 8.61 (d, $J = 6.6$ Hz, 2H, H13 and H15), 8.78 (d, $J = 6.9$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 15.1$ (C9 or C10), 20.6 (C7), 21.7 (C9 or C10), 22.2 (CH_3–R^3), 22.5 (C3), 25.2 (C8), 30.9 (C5), 33.7 (C4), 39.9 (C6), 47.3 (C2), 80.2 (C1), 85.9 (C11), 127.6 (C13 and C15), 141.2 (C14), 159.1 (C12 and C16); anion: 113.1, 117.5, 121.9, 125.8. Elemental analysis calcd (%) for $C_{19}H_{28}F_6N_2O_5S_2$ (542.69): C 42.05, H 5.21, N 5.16. Found: 42.10, H 5.28, N 5.03.

4.3.29. 4-Ethyl-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]pyridinium bis(trifluoromethanesulfonyl)imide 6e. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.46$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.88 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.30 (m, 5H, H2, H5 and CH_3–R^3), 1.64 (m, 2H, Hb-3 and Hb-4), 1.96 (m, 2H, H8 and Hb-6), 3.00 (q, $J = 7.4$ Hz, 2H, CH_2–R^3), 3.38 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.82 and 5.86 (d, $J = 10.2$ Hz, 2H, AB system, H11), 7.89 (d, $J = 6.3$ Hz, 2H, H13 and H15), 8.78 (d, $J = 6.9$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 13.2$ (CH_3–R^3), 15.3 (C9 or C10), 20.8 (C7), 21.8 (C9 or C10), 22.6 (C3), 25.4 (C8), 29.1 (CH_2–R^3), 31.1 (C5), 33.8 (C4), 40.1 (C6), 47.6 (C2), 81.5 (C1), 86.9 (C11), 127.5 (C13 and C15), 142.1 (C12 and C16), 166.7 (C14); anion: 113.1, 117.6, 121.9, 126.0. Elemental analysis calcd (%) for $C_{20}H_{30}F_6N_2O_5S_2$ (556.72): C 43.14, H 5.44, N 5.03. Found: C 43.09, H 5.49, N 5.16.

4.3.30. 4-*tert*-Butyl-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]-pyridinium bis(trifluoromethanesulfonyl)imide 6f. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.40$ (d, $J = 7.1$ Hz, 3H, H9 or H10), 0.89 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.35 (m, 11H, H2, CH_3–R^3, H5), 1.63 (m, 2H, Hb-3 and Hb-4), 1.97 (m, 2H, H8 and Hb-6), 3.36 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.80 (t, $J = 10.4$ Hz, 2H, AB system, H11), 8.06 (d, $J = 7.1$ Hz, 2H, H13 and H15), 8.83 (d, $J = 6.9$ Hz, 2H, H12 and H16); ^{13}C NMR ($CDCl_3$): $\delta = 14.9$ (C9 or C10), 20.6 (C7), 21.7 (C9 or C10), 22.4 (C3), 25.2 (C8), 29.7 (CH_3–R^3), 30.9 (C5), 33.7 (C4), 36.7 (C–R^3), 39.9 (C6), 47.4 (C2), 78.1 (C1), 86.5 (C11), 125.2 (C13 and C15), 142.3 (C12 and C16), 173.3 (C14); anion: 113.3, 117.5, 121.8, 126.0. Elemental analysis calcd (%) for $C_{22}H_{34}F_6N_2O_5S_2$ (584.78): C 45.18, H 5.87, N 4.79. Found: C 45.25, H 5.94, N 4.63.

4.3.31. 3-Carbamoyl-1-[(1*R*,2*S*,5*R*)-(−)-menthoxymethyl]-pyridinium bis(trifluoromethanesulfonyl)imide 6g. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.50$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.93 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.35 (m, 2H, H2 and H5), 1.63 (m, 2H, Hb-3 and Hb-4), 1.99 (m, 2H, H8 and Hb-6), 3.46 (td, $J = 10.4$, 4.1 Hz, 1H, H1), 5.96 and 6.01 (d, $J = 10.2$ Hz, 2H, AB system, H11), 6.87 (s, 1H, NH_2), 7.62 (s, 1H, NH_2), 8.18 (t, $J = 7.7$ Hz 1H, H15), 9.02 (d, $J = 7.4$ Hz, 2H, H14 and H16), 9.38 (s, 1H, H12); ^{13}C NMR ($CDCl_3$): $\delta = 15.2$ (C9 or C10), 20.7 (C7), 21.7 (C9 or C10), 22.5 (C3), 25.4 (C8), 31.1 (C5), 33.7 (C4), 40.1 (C6), 47.6 (C2), 82.2 (C1), 88.0 (C11), 128.3 (C15), 134.0 (C13), 142.5 (C14), 143.9 (C16), 145.6 (C12), 163.0 ($CONH_2$); anion: 113.1, 117.3, 121.6, 125.8. Elemental analysis calcd (%) for $C_{19}H_{27}F_6N_3O_6S_2$ (571.69): C 39.91, H 4.77, N 7.35. Found: C 39.99, H 4.85, N 7.21.

4.3.32. 1-[(1*R*,2*S*,5*R*)-(−)-Menthoxymethyl]-3-(dimethylamino)pyridinium bis(trifluoromethanesulfonyl)imide 6h. ^{1}H NMR ($CDCl_3$, 25 °C): $\delta = 0.51$ (d, $J = 6.9$ Hz, 3H, H9 or H10), 0.91 (m, 9H, Ha-4, H7, H9 or H10, Ha-6 and Ha-3), 1.37 (m, 2H, H2 and H5), 1.64 (m, 2H, Hb-3 and Hb-4), 2.03 (m, 2H, H8 and Hb-6), 3.1 (s, 6H, $N(CH_3)_2$), 3.38 (td, $J = 10.7$ Hz, $J = 4.4$ Hz, 1H, H1), 5.75 and 5.80 (d, $J = 10.2$ Hz, 2H, AB system, H11), 7.63 (m, 1H, H15), 7.75 (m, 1H, H14), 8.03 (m, 2H, H16 and H12); ^{13}C NMR ($CDCl_3$): $\delta = 15.3$ (C9 or C10), 20.7 (C7), 21.7 (C9 or C10), 22.5 (C3), 25.4 (C8), 31.0 (C5), 33.7 (C4), 39.7 ($N(CH_3)_2$), 40.0 (C6), 47.5 (C2), 81.3 (C1), 87.4 (C11), 124.0 (C15), 126.5 (C14), 127.4 (C16), 127.8 (C12), 148.3 (C13); anion: 113.3, 117.5, 121.8, 126.0. Elemental analysis calcd (%) for $C_{20}H_{31}F_6N_3O_5S_2$ (571.74): C 42.01, H 5.48, N 7.35. Found: C 42.15, H 5.41, N 7.48.

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References

1. Menschutkin, J. *J. Russ. Phys. Chem. Soc.* **1902**, *34*, 411; through *Chem. Zentr.* **1902**, *73*, 86.
2. Ding, J.; Armstrong, D. W. *Chirality* **2005**, *17*, 281–292.
3. Xue, H.; Verma, R.; Shreeve, J. M. *J. Fluorine Chem.* **2006**, *127*, 159–176.
4. Pernak, J.; Feder-Kubis, J. *Chem. Eur. J.* **2005**, *11*, 4441–4449.
5. Ding, J.; Desikan, V.; Han, X.; Xiao, T. L.; Ding, R.; Jenks, W. S.; Armstrong, D. W. *Org. Lett.* **2005**, *7*, 335–337.
6. Dawkins, D.; Jenkins, P. R. *Tetrahedron: Asymmetry* **1992**, *3*, 833–836.
7. Lakshman, M. K.; Chaturvedi, S.; Kole, P. L.; Windels, J. H.; Myers, M. B.; Brown, M. A. *Tetrahedron: Asymmetry* **1997**, *8*, 3375–3378.
8. Pernak, J.; Kalewska, J.; Ksycińska, H.; Cybulski, J. *Eur. J. Med. Chem.* **2001**, *36*, 899–907.
9. Pernak, J.; Zygadło, M.; Cieniecka-Rosłonkiewicz, A. *J. Surfactants Deterg.* **2005**, *8*, 233–239.
10. Pernak, J.; Branicka, M. *Ind. Eng. Chem. Res.* **2004**, *43*, 1966–1974.
11. Fox, J.; Hepworth, J. D.; Hallas, G. *J. Chem. Soc., Perkin Trans.* **1973**, 68–69.
12. Adrianov, K. A.; Mamedov, A. A.; Volkova, L. M.; Klabunovskii, E. I. *Izv. Akad. Nauk SSSR Ser. Chem.* **1969**, 2305–2307.