

Ionic liquids lubricants: when chemistry meets tribology

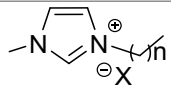
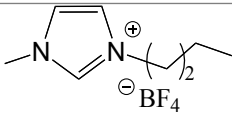
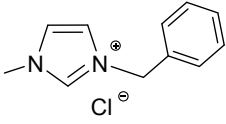
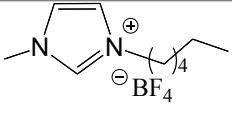
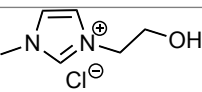
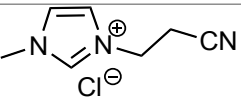
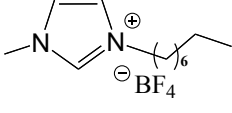
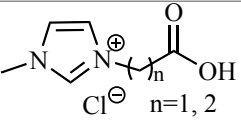
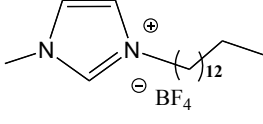
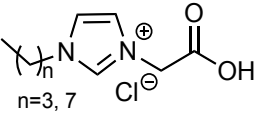
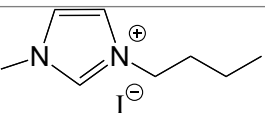
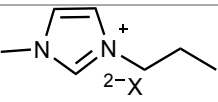

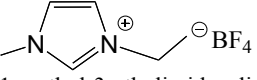
Meirong Cai,^a Qiangliang Yu,^a Weimin Liu,^{* a,b} Feng Zhou,^{*a}

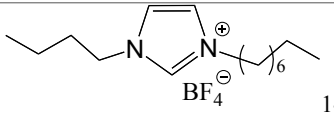
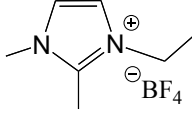
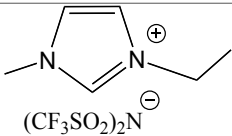
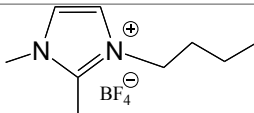
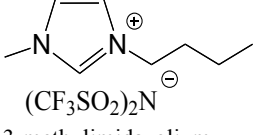
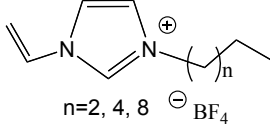
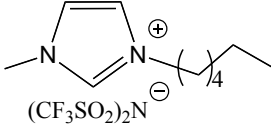
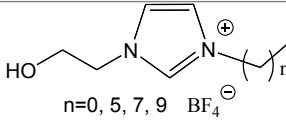
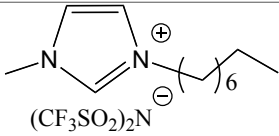
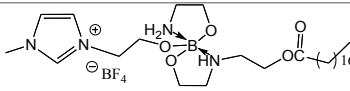
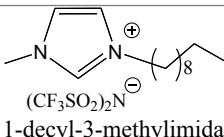
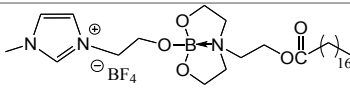
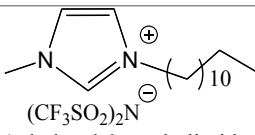
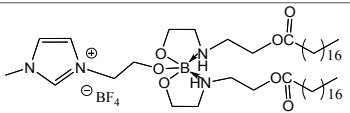
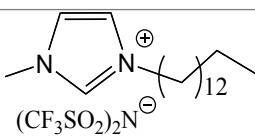
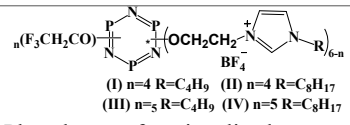
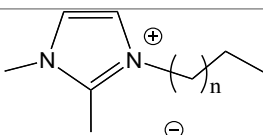
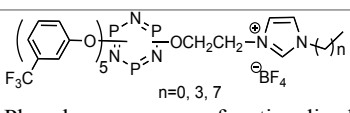
a, State Key Laboratory of Solid Lubrication, Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, Lanzhou, 730000, China

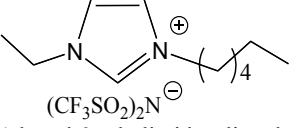
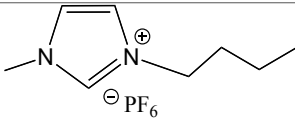
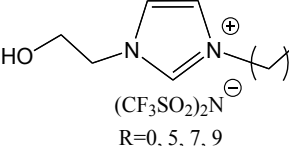
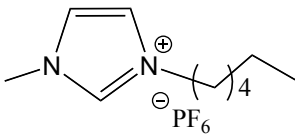
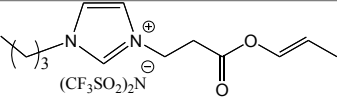
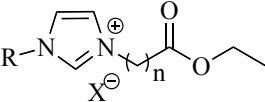
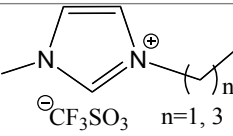
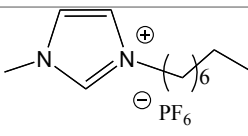
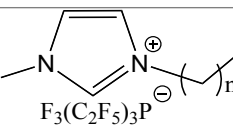
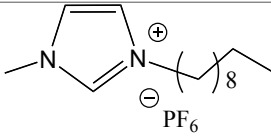
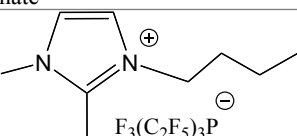
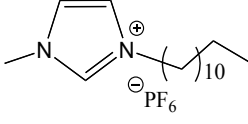
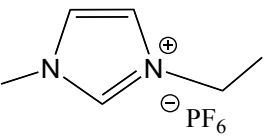
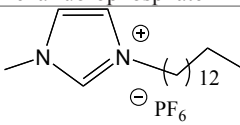
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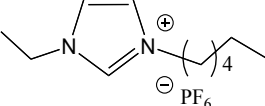
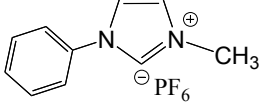
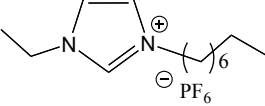
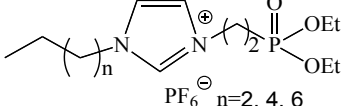
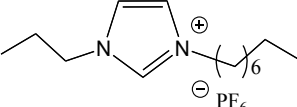
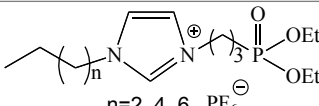
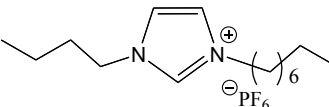
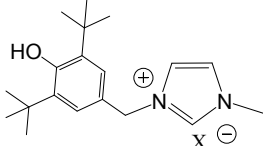
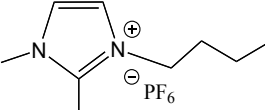
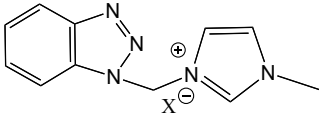
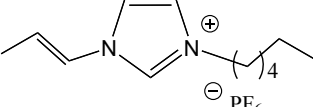
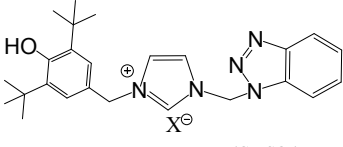
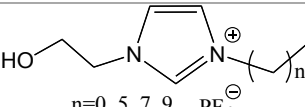
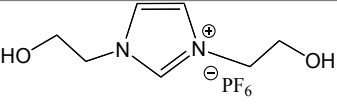
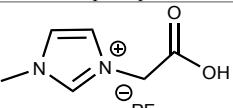
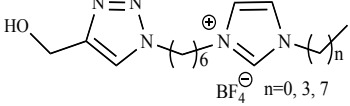
*, Corresponding authors zhouf@licp.cas.cn, wmliu@licp.cas.cn

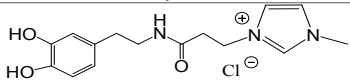
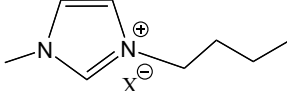
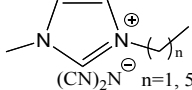
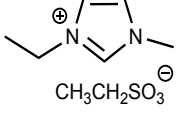
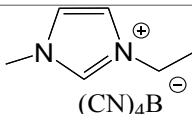
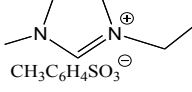
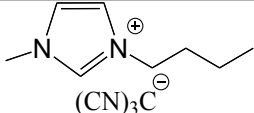
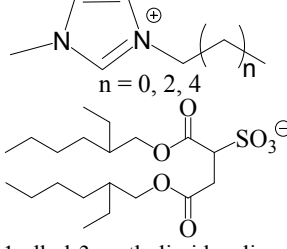
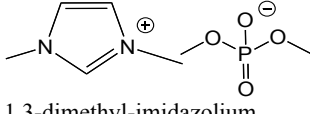
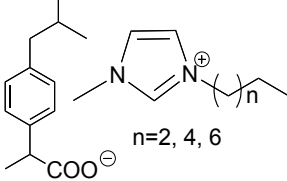
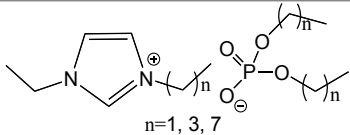
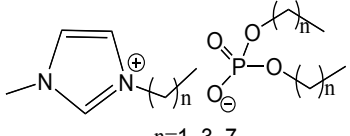
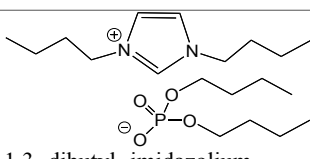
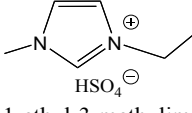
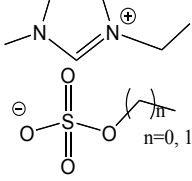
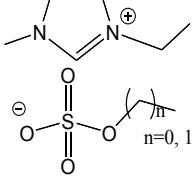
Table S1 Overview of ionic liquids research

Chemical structures and names of ILs	Tribo-materials	
 <p>X = Cl, Br; n = 2, 3, 5, 7, 11 1-alkyl-3-methylimidazolium bromide/chloride</p>	Steel/Steel ¹ , Steel/Al ² , Steel/Polymer ³ , Film ⁴⁻⁶	Si/Si ₃ N ₄ ²² Si ₃ N ₄ / Si ₃ N ₄ ²² , Al ₂ O ₃ /Film ²³
 <p>1-butyl-3-methylimidazolium tetrafluoroborate</p>	Steel/Steel ^{11, 24-32} , Steel/Cu ²⁸ , Film ³³⁻³⁶ , Steel/Film ³⁷ , Steel/Coated, (chromium/silica layer) glass ²⁶ , Steel/DLC ^{38, 39} Polymer/Polymer ²⁹	
 <p>1-benzyl-3-methylimidazolium chloride</p>	Steel/ Ti ⁷	
 <p>1-hexyl-3-methylimidazolium tetrafluoroborate</p>	Steel/Steel ^{25, 26, 40-54} , Steel/Al ^{15-19, 40, 41, 55, 56} , Steel/Cu ^{40, 41} , Steel/SiO ₂ ⁴⁰ , Steel/Si(100) ⁴⁰ , Steel/Sialon ⁴⁰ , Si ₃ N ₄ /SiO ₂ ⁴⁰ , Si ₃ N ₄ /Sialon ⁴⁰ , Polymer/Steel ²⁰ , Steel/PTFE ⁵² Steel/Coated (chromium/silica layer) glass ²⁶ , Film ⁵⁷	
 <p>3-(2-hydroxyethyl)-1-methylimidazolium chloride</p>	Film ^{4, 5}	
 <p>1-propionitrile-3-methylimidazolium chloride</p>	Film ^{4, 5}	
 <p>1-octyl-3-methylimidazolium tetrafluoroborate</p>	Steel/Steel ⁵⁸⁻⁶⁰ , Steel/Al ^{15, 16, 18, 19, 55, 56, 61} , Steel/Ti ^{7, 62, 63} , Steel/Mg ⁶⁴ , Polymer/Steel ^{20, 65} , ZrO ₂ /Steel ⁶⁶ Steel/Steel ⁶⁷	
 <p>carboxyalkyl-3-methylimidazolium chloride n = 1, 2</p>	Film ^{4, 5, 8-10}	
 <p>1-tetradecyl-3-methylimidazolium tetrafluoroborate</p>	Steel/Steel ⁶⁸	
 <p>1-carboxymethyl-3-alkylimidazolium chloride n = 3, 7</p>	Film ¹⁰	
 <p>1-butyl-3-methylimidazolium iodide</p>	Steel/Steel ¹¹ , Steel/Al ¹² , WC/Al ¹³	
 <p>1-propyl-3-methylimidazolium carbonate/sulfite X = CO₃, SO₃</p>	Film ⁶	
 <p>1-hexadecyl-3-methylimidazolium tetrafluoroborate</p>	Steel/Steel ^{40, 41, 47, 69} , Steel/Al ⁷⁰	
 <p>1-methyl-3-ethylimidazolium tetrafluoroborate</p>	Steel/Steel ¹⁴ , Steel/Al ^{15, 16 17-19} , Steel/Ti ⁷ , Polymer/Steel ^{20, 21} , SiO ₂ /Si ₃ N ₄ ²² , Poly-	

 <p>octyl-3-butylimidazolium tetrafluoroborate</p>	Steel/Mg ⁶⁴ , Steel/Coating ⁷¹	imidazolium tetrafluoroborate	
 <p>1-ethyl-2,3-dimethylimidazolium tetrafluoroborate</p>	Si ₃ N ₄ / Si ₃ N ₄ ⁷²	 <p>(CF₃SO₂)₂N⁻ 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide</p>	Steel/Steel ^{1, 29, 50, 79-83} , Steel/Ti ^{84, 85} , Steel/Al ⁸⁵ , Steel/Al-Ti alloy ⁸⁵ , Glass/brush ⁸⁶ , WC/Al ¹³ , Si ₃ N ₄ /Steel ⁸⁷ , Polymer/Polymer ²⁹ , Al ₂ O ₃ /Film ²³
 <p>1-butyl-2,3-dimethylimidazolium tetrafluoroborate</p>	SiO ₂ /Si ₃ N ₄ ^{22, 73} , Poly-Si/Si ₃ N ₄ ^{22, 73} , Si ₃ N ₄ / Si ₃ N ₄ ^{22, 73}	 <p>(CF₃SO₂)₂N⁻ 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide</p>	Steel/Steel ^{28, 29, 49, 50, 83, 88-97} , Steel/Ti ⁸⁴ , Steel/Cu ^{28, 93} , Steel/CaF ₂ ⁹⁸ , Si ₃ N ₄ /Steel ⁸⁷ , Steel/Coating ⁹⁹ , Polymer/Polymer ²⁹
 <p>n=2, 4, 8 1-alkyl-3-vinyl-imidazolium tetrafluoroborate</p>	Steel/Steel ⁴⁷	 <p>(CF₃SO₂)₂N⁻ hexyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide</p>	Steel/Steel ^{30, 48, 50, 79, 80, 83, 88, 100-103} , Steel/Al ¹⁰² , Cu/Cu ¹⁰⁴ , Steel/Cu ^{102, 103} , Si ₃ N ₄ /Steel ¹⁰⁵ , Si ₃ N ₄ /Ti ₃ SiC ₂ ¹⁰⁶
 <p>n=0, 5, 7, 9 1-(2-hydroxyethyl)-3-alkylimidazolium tetrafluoroborate</p>	Steel/Steel ^{74, 75}	 <p>(CF₃SO₂)₂N⁻ 1-octyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide</p>	Steel/Steel ^{1, 107} , Steel/Al ² Ti/Steel ⁸⁴ , Film ¹⁰⁸
 <p>Borate ester-functionalized imidazolium tetrafluoroborate</p>	Steel/DLC ⁷⁶	 <p>(CF₃SO₂)₂N⁻ 1-decyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide</p>	Fe Alloy ¹⁰⁹ , Steel/Al ^{2, 110, 111}
 <p>Borate ester-functionalized imidazolium tetrafluoroborate</p>	Steel/DLC ⁷⁶	 <p>(CF₃SO₂)₂N⁻ 1-dodecyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide</p>	Steel/Steel ^{80, 81, 88}
 <p>Borate ester-functionalized imidazolium tetrafluoroborate</p>	Steel/DLC ⁷⁶	 <p>(CF₃SO₂)₂N⁻ 1-tetradecyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide</p>	Steel/Steel ⁶⁷
 <p>(I) n=4 R=C₄H₉ (II) n=4 R=C₈H₁₇ (III) n=5 R=C₄H₉ (IV) n=5 R=C₈H₁₇ Phosphazene functionalized imidazolium tetrafluoroborate</p>	Steel/Steel ⁷⁷	 <p>(CF₃SO₂)₂N⁻ n=2, 4, 6 1-alkyl-2,3-dimethylimidazolium bis(trifluoromethylsulfonyl)imide</p>	Steel/Steel ^{14, 112} , Steel/Steel ¹⁰⁰ , Si ₃ N ₄ /Steel ¹⁰⁵ , Film ^{113, 114}
 <p>n=0, 3, 7 Phosphazene functionalized</p>	Steel/Steel ⁷⁸		

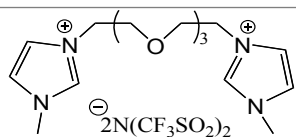
 <p>1-hexyl-3-ethylimidazolium bis(trifluoromethylsulfonyl)-imide</p>	Steel/Steel ⁶⁹	 <p>1-butyl-1-methylimidazolium hexafluorophosphate</p>	Steel/Steel ^{1, 11, 25, 26, 29-31, 45, 59, 120-123} , Steel/Al ² , Film ^{33, 35, 36, 124-128} , Steel/Coated (chromium/silica layer) glass ²⁶ , Steel/Sapphire ¹²⁹ , Steel/DLC ¹²³ , Polymer/Polymer ²⁹ PEEK/steel ¹³⁰
 <p>1-hydroxyethyl-3-alkylimidazolium bis(trifluoromethylsulfonyl)-imide R=0, 5, 7, 9</p>	Steel/Steel ¹¹⁵	 <p>1-hexyl-3-methylimidazolium hexafluorophosphate</p>	Steel/Steel ^{26, 42, 43, 45, 54, 58, 59, 120, 131-133} , Steel/Al ^{2, 15-19, 134-137} , Steel/Ti ^{7, 62, 63} , Cu/DLC ¹³⁸ , Cu/Cu ¹³⁹ , Polymer/Steel ^{20, 140} , Polymer/AISI 316L ^{141, 140} , Si ₃ N ₄ /Steel ¹⁰⁵ , Steel/coated (chromium/silica layer) glass ²⁶ , Steel/coating ^{142, 143} , Steel/film ¹⁴⁴ , Steel/Sapphire ¹²⁹ , Steel/DLC ^{138, 145-147} , ZrO ₂ /DLC ¹³⁸ , Al ₂ O ₃ /DLC ¹³⁸ , SiC/DLC ¹³⁸ , WC/DLC ¹³⁸ , Si ₃ N ₄ /DLC ¹³⁸ , Film ⁵⁷
 <p>Poly(1-(2-methacryloyloxy)ethyl-3-butylimidazolium bis(trifluoromethylsulfonyl)-imide)</p>	Brushes ⁸⁶	 <p>1-ethoxycarbonylmethyl-3-alkylimidazolium compounds bis(trifluoromethylsulfonyl)-imide, tetrafluoroborate R=CH₃, C₄H₉, C₈H₁₇; n=1, 2 X=BF₄, (CF₃SO₂)₂N</p>	Steel/Steel ^{116, 117}
 <p>1-alkyl-3-methylimidazolium Triflate n=1, 3</p>	Steel/Steel ²⁹ , Steel/Al ¹⁵⁻¹⁹ , Polymer/Steel ²⁰ , Polymer/Polymer ²⁹ , Steel/CaF ₂ ⁹⁸	 <p>1-octyl-3-methylimidazolium hexafluorophosphate</p>	Steel/Steel ^{1, 45, 60, 120, 148} , Steel/Al ² , Steel/Mg ⁶⁴ , Steel/Sapphire ¹²⁹ , Steel/DLC ¹⁴⁹ , ZrO ₂ /Steel ⁶⁶ , Steel/Coating ¹⁵⁰ ,
 <p>1-alkyl-3-methylimidazolium tris(pentafluoroethyl)trifluorophosphate n=1, 5, 17</p>	Steel/Steel ⁷⁹ , Steel/Al ⁶¹ , silica/silicon ¹¹⁸ , Steel/Steel ⁷⁹ , silica/silicon ¹¹⁸	 <p>1-decyl-3-methylimidazolium Hexafluorophosphate</p>	Steel/Steel ⁴⁵ , ZrO ₂ /Steel ⁶⁶ ,
 <p>1-tetradecyl-3-methylimidazolium tris(pentafluoroethyl)trifluorophosphate</p>	Steel/Steel ¹¹⁹	 <p>1-dodecyl-3-methylimidazolium hexafluorophosphate</p>	Steel/Steel ^{1, Film} ¹²⁷
 <p>1-ethyl-3-methylimidazolium hexafluorophosphate</p>	Steel/Steel ^{1, 25, 49, 67} , Al ₂ O ₃ /Film ²³	 <p>1-tetradecyl-3-methylimidazolium hexafluorophosphate</p>	Steel/Steel ⁶⁷

 <p>1-hexyl-3-ethylimidazolium hexafluorophosphate</p>	<p>Steel/Steel^{120, 151}, Steel/Al¹⁵², Steel/Cu-Sn alloy¹⁵³, Steel/ Ni-Si₃N₄ coating¹⁵⁴ Ni coating¹⁵⁵</p>	 <p>1-phenyl-3-methylimidazolium Hexafluorophosphate</p>	<p>Film¹²⁸</p>
 <p>1-octyl-3-ethylimidazolium Hexafluorophosphate</p>	<p>Steel/Steel¹²⁰</p>	 <p>1-(3'-O,O-diethylphosphonyln-ethyl)-3-alkylimidazolium Hexafluorophosphate</p>	<p>Steel/Al¹⁶³</p>
 <p>1-octyl-3-propylimidazolium Hexafluorophosphate</p>	<p>Steel/Steel^{120, 156}, Steel/Al¹⁷⁰</p>	 <p>1-(3'-O,O-diethylphosphonyln-propyl)-3-alkylimidazolium Hexafluorophosphate</p>	<p>Steel/Al^{170, 163}</p>
 <p>1-octyl-3-butyl-imidazolium Hexafluorophosphate</p>	<p>Steel/Steel¹⁴⁸, Steel/Mg⁶⁴, Steel/Cu¹⁵⁷, Ni coating^{155, 157}, Steel/DLC¹⁴⁹</p>	 <p>X=PF₆, BF₄, N(CF₃SO₂)₂</p> <p>1-(3,5-ditert-butyl-4-hydroxybenzyl)-3-methylimidazolium hexafluorophosphate/tetrafluoroborate/bis(trifluoromethylsulfonyl)-imide</p>	<p>Steel/Steel¹⁶⁴</p>
 <p>1-butyl-2,3-dimethyl imidazolium Hexafluorophosphate</p>	<p>Steel/Steel¹⁴, Si₃N₄/ Si₃N₄⁷² MEMS¹⁵⁸,</p>	 <p>X= PF₆, BF₄, N(CF₃SO₂)₂</p> <p>1-(1H-benzo[d][1,2,3]triazol-1-yl)methyl)-3-methylimidazolium hexafluorophosphate/tetrafluoroborate/bis(trifluoromethylsulfonyl)-imide</p>	<p>Steel/Steel^{165, 166}, Steel/Cu¹⁶⁷</p>
 <p>1-allyl-3-hexyl imidazolium Hexafluorophosphate</p>	<p>Film¹⁵⁹</p>	 <p>X=PF₆, BF₄, N(CF₃SO₂)₂</p> <p>1-((1H-benzo[d][1,2,3]triazol-1-yl)methyl)-3-(3,5-di-tert-butyl-4-hydroxybenzyl)-3-methylimidazolium with hexafluorophosphate/tetrafluoroborate/bis(trifluoromethylsulfonyl)-imide</p>	<p>Steel/Steel¹³³</p>
 <p>1-hydroxyethyl-3-alkylimidazolium hexafluorophosphate</p>	<p>Steel/Steel^{159, 160}, Film^{128, 159},</p>	 <p>1,3-di(2-hydroxyethyl)imidazolium hexafluorophosphate</p>	<p>Film¹⁶¹</p>
 <p>1-carboxymethyl-3-butylimidazolium hexafluorophosphate</p>	<p>Film^{128, 162}</p>	 <p>BF₄⁻ n=0, 3, 7</p> <p>1-(6-(4-hydroxymethyl)-1,2,3-triazolyl)hexyl)-3-alkylimidazolium</p>	<p>Steel/Steel⁵¹</p>

<p>tetrafluoroborate,</p>  <p>1-N-[2-(3,4-Dihydroxyphenyl)ethyl]propionamide-3-methylimidazolium chloride</p>	Film ¹⁶⁸	<p>1-butyl-3-methylimidazolium o-butyl phosphonate</p>  <p>X = NO₃, ClO₄</p> <p>1-butyl-3-methylimidazolium nitrate, perchlorate</p>	SAM ¹⁷² Film ³⁵
 <p>(CN)₂N⁻ n=1, 5</p> <p>1-alkyl-3-methylimidazolium dicyanamide</p>	Steel/Steel ^{11, 169} , Steel/Steel ⁵² , Steel/PTFE ⁵² , Steel/CrN ¹⁷⁰ , Steel/TiN ¹⁷⁰ , Steel/TiCN ¹⁷⁰ , Steel/ TiAlN ¹⁷⁰ , Steel/DLC ¹⁷⁰	 <p>CH₃CH₂SO₃⁻</p> <p>1-ethyl-3-methylimidazolium ethyl sulfate</p>	MEMS ¹⁷³
 <p>(CN)₄B⁻</p> <p>1-ethyl-3-methylimidazolium Tetracyanoborate</p>	Steel/Steel ^{97, 169}	 <p>CH₃C₆H₄SO₃⁻</p> <p>1-ethyl-3-methylimidazolium tosylate</p>	Steel/Al ^{15, 16} , Polymer/Steel ^{20, 174}
 <p>(CN)₃C⁻</p> <p>1-butyl-3-methylimidazolium Tycyanomethanide</p>	Steel/Steel ^{11, 97} , Steel/CrN ¹⁷⁰ , Steel/TiN ¹⁷⁰ , Steel/TiCN ¹⁷⁰ , Steel/ TiAlN ¹⁷⁰ , Steel/DLC ¹⁷⁰	 <p>n = 0, 2, 4</p> <p>1-alkyl-3-methylimidazolium bis(2-ethylhexyl)sulfosuccinate</p>	Steel/Steel ²⁸ , Steel/Cu ²⁸
 <p>1,3-dimethyl-imidazolium Dimethylphosphate</p>	Steel/Steel ²⁵	 <p>n=2, 4, 6</p> <p>1-alkyl-3-methylimidazolium ibuprofen</p>	Steel/Steel ¹⁰³ , Steel/Cu ¹⁰³
 <p>n=1, 3, 7</p> <p>1-alkyl-3-ethylimidazolium Diethylphosphate</p>	Steel/Steel ⁴⁴ , Si ₃ N ₄ /Ti ₃ SiC ₂ ¹⁷¹	 <p>n=1, 3, 7</p> <p>1-alkyl-3-methylimidazolium Dialkylphosphate</p>	Steel/Steel ¹³²
 <p>1,3- dibutyl -imidazolium dibutylphosphate</p>	Steel/Al ¹³⁷	 <p>HSO₄⁻</p> <p>1-ethyl-3-methylimidazolium bisulfate</p>	Steel/Steel ¹⁷⁵ , Steel/Al ¹⁷⁵ , Steel/Cu ¹⁷⁵
 <p>n=0, 1, 3</p> <p>1-ethyl-3-methylimidazolium alkyl sulfate</p>	Steel/Al ¹³⁵	 <p>n=0, 1, 3</p> <p>1-ethyl-3-methylimidazolium alkyl sulfate</p>	Steel/Steel ^{175, 176} , Steel/Al ¹⁷⁵ , Steel/Cu ¹⁷⁵ , Silica/Silicon ¹⁷⁷ ,

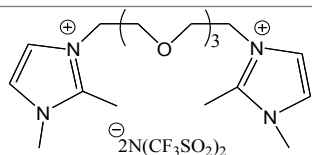
	Steel/Steel ^{25, 178, 179} Film ^{124, 125}		Steel/Steel ⁹⁶
	Steel/Steel ^{29, 175} , Steel/Al ¹⁷⁵ , Steel/Cu ¹⁷⁵ , Polymer/Polymer ²⁹		Steel/Steel ⁹⁶
	Steel/Steel ^{29, 175} , Steel/Al ¹⁷⁵ , Steel/Cu ¹⁷⁵ , PDMS/PDMS ¹⁸⁰ Polymer/Polymer ²⁹		Steel/Steel ¹⁸²
	Steel/Steel ¹⁷⁹		Film ¹⁸³
	SiO ₂ / SiO ₂ ¹⁸¹		Film ¹⁸³
	Film ^{33, 57}		Steel/Steel ¹⁵¹
	Steel/Steel ²⁵		Steel/Steel ¹⁸⁴ , Si ₃ N ₄ /Steel ¹⁰⁵
	Steel/Steel ²⁵		Film ¹²⁶

hydroxyethyl-1*H*-imidazolium-1-yl)
bis(trifluoromethylsulfonyl)-imide



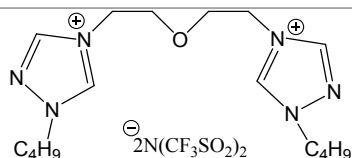
Steel/Steel¹⁸⁵

1,1'-(3,6,9-trioxaundecane-1,11-diyl)bis(3-dimethyl-1*H*-imidazolium-1-yl)
bis(trifluoromethyl sulfonyl)-imide



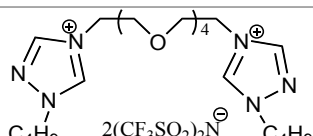
Steel/Steel¹⁸⁶

1,1'-(3,6,9-trioxaundecane-1,11-diyl)bis(2,3-dimethyl-1*H*-imidazolium-1-yl)
bis(trifluoromethyl sulfonyl)-imide



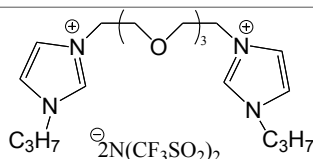
Steel/Steel¹⁸⁶

4,4'-(3-oxapentane-1,5-diyl)bis(1-butyl-1*H*-triazolium-4-yl) Bis
(trifluoromethylsulfonyl)-imide



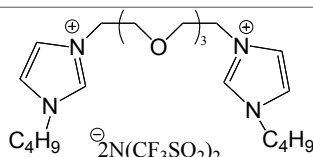
Steel/Steel¹⁸⁶

4,4'-(3,6,9,12-tetraoxatetradecane-1,14-diyl)bis(1-butyl-1*H*-triazolium-4-yl) bis(trifluoromethyl sulfonyl)-imide



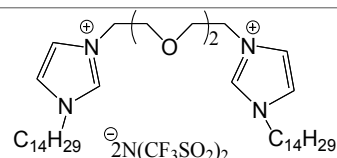
Steel/Steel¹⁸⁶

1,1'-(3,6,9-trioxaundecane-1,11-diyl)bis(3-propyl-1*H*-imidazolium-1-yl) bis(trifluoromethyl sulfonyl)-imide



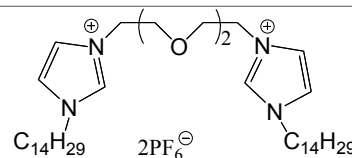
Steel/Steel¹⁸⁶

1,1'-(3,6,9-trioxaundecane-1,11-diyl)bis(3-butyl-1*H*-imidazolium-1-yl) bis(trifluoromethylsulfonyl)-imide



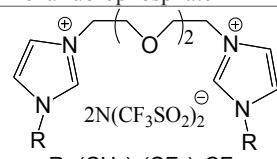
Steel/Steel¹⁸⁷

1,1'-(3,6-dioxaoctane-1,8-diyl)bis(3-tetradecyl-1*H*-imidazolium-1-yl)
bis(trifluoromethyl sulfonyl)-imide



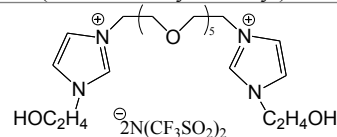
Steel/Steel¹⁸⁷

1,1'-(3,6-dioxaoctane-1,8-diyl)bis(3-tetradecyl-1*H*-imidazolium-hexafluorophosphate



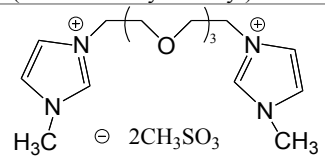
Steel/Steel¹⁸⁷

1,1'-(3,6-dioxaoctane-1,8-diyl)bis(3-perfluorodecyl-1*H*-imidazolium-1-yl)
bis(trifluoromethyl sulfonyl)-imide



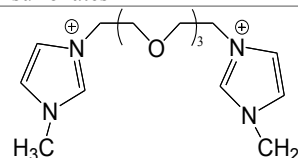
Film¹²⁶

1,1'-(3,6,9,12,15-pentaoxapentadecane-1,15-diyl)bis(3-hydroxyethyl-1*H*-imidazolium-1-yl) Bis
(trifluoromethylsulfonyl)-imide



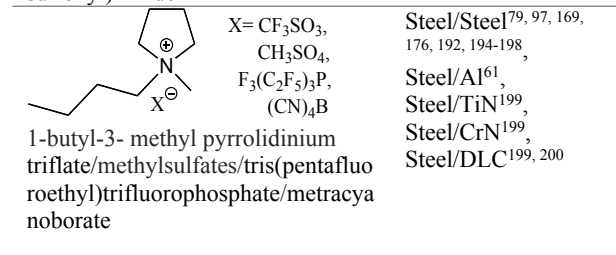
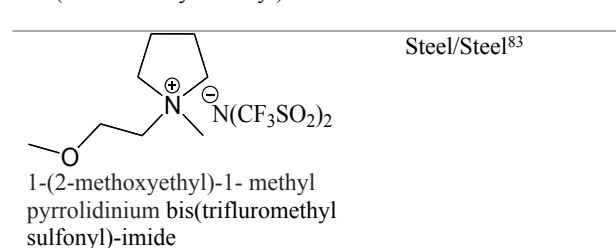
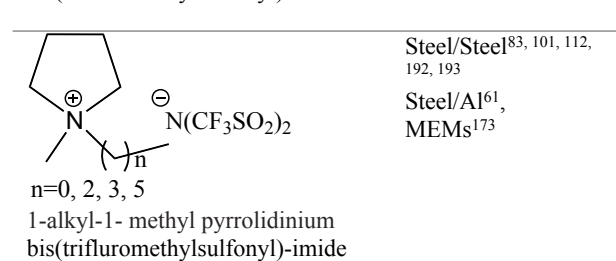
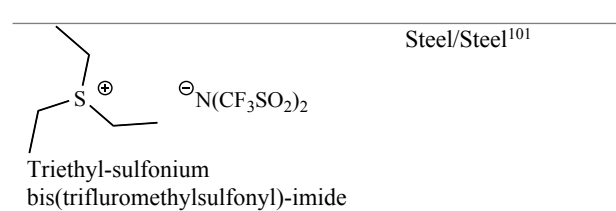
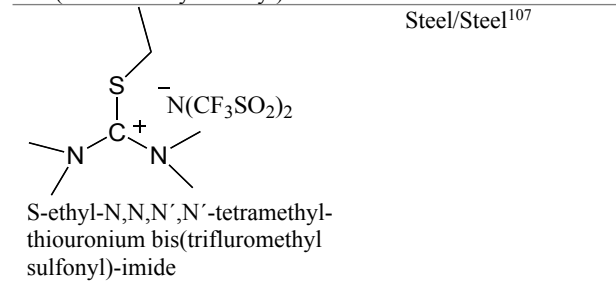
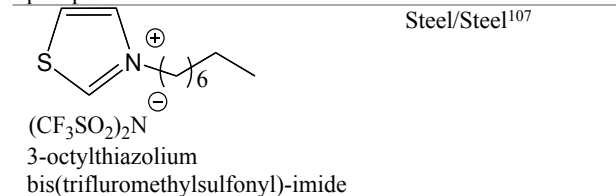
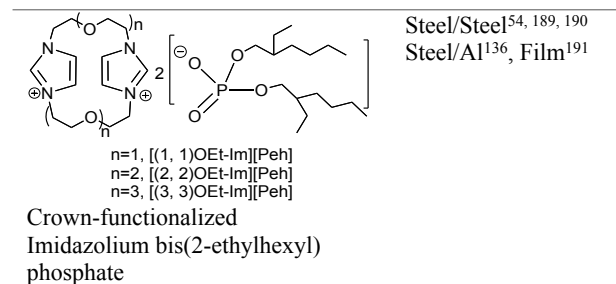
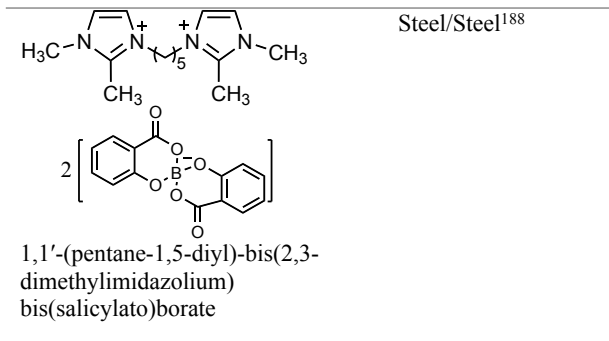
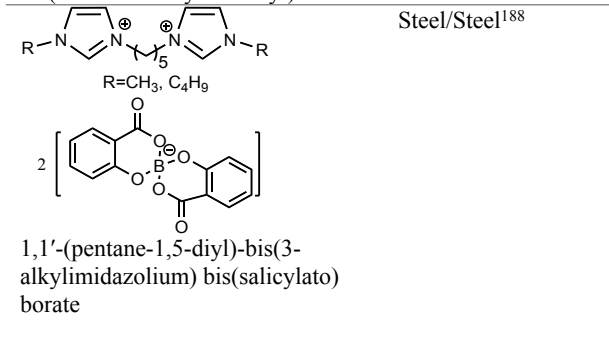
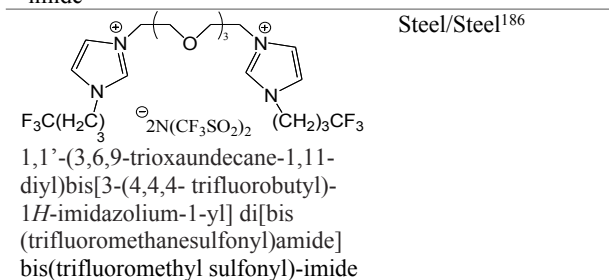
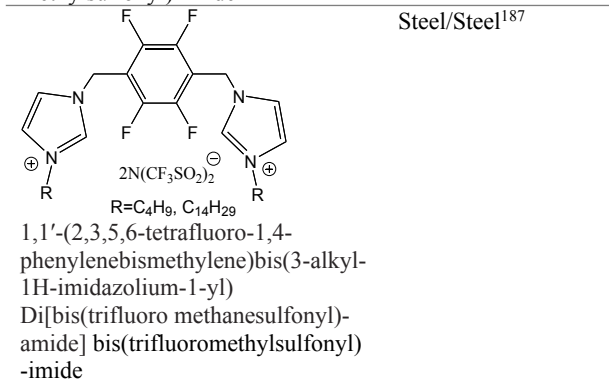
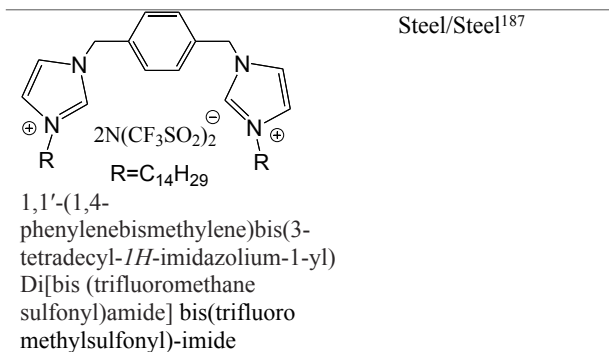
Steel/Steel¹⁸⁵

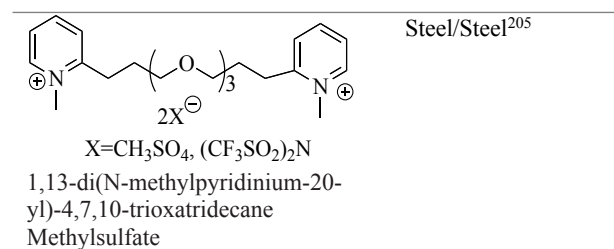
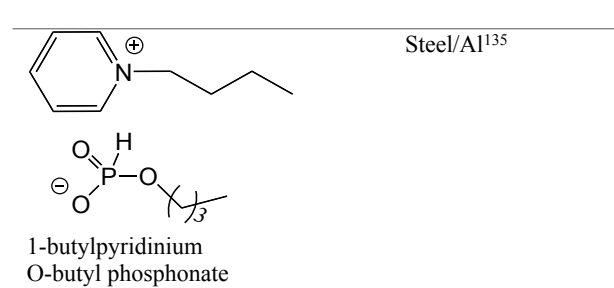
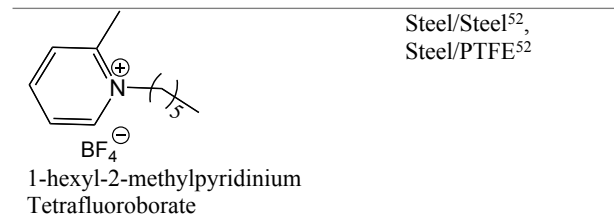
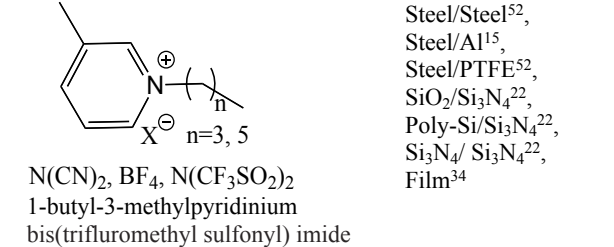
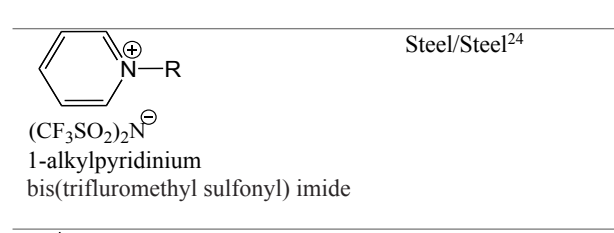
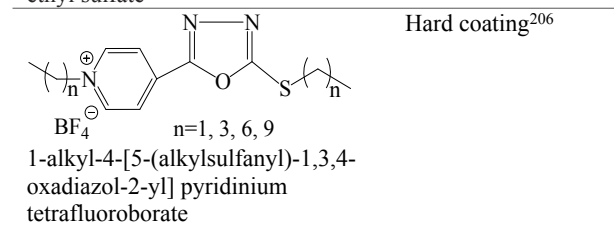
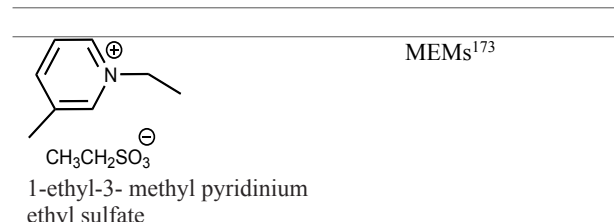
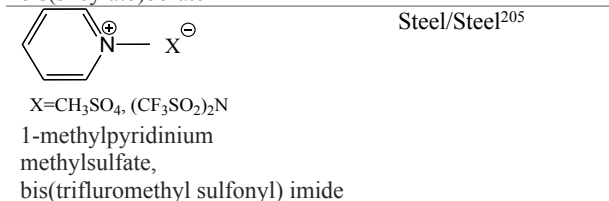
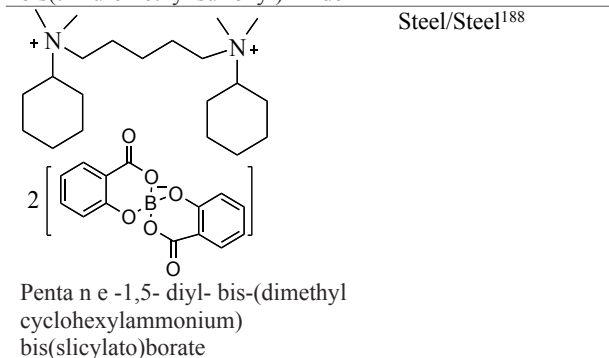
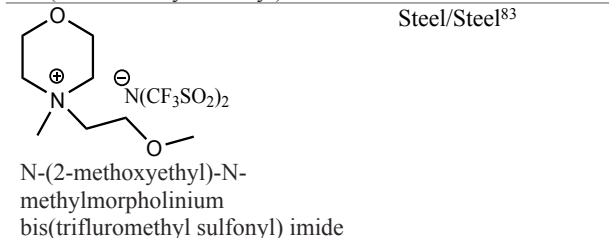
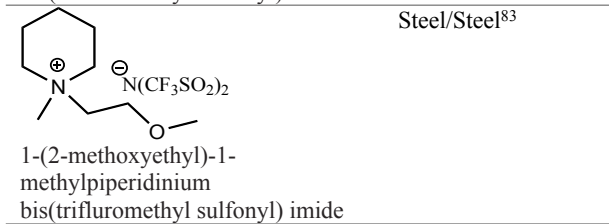
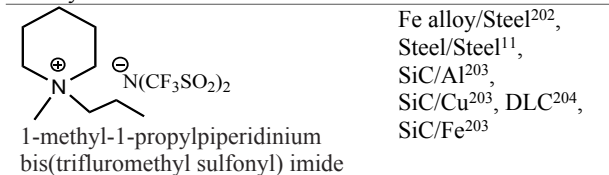
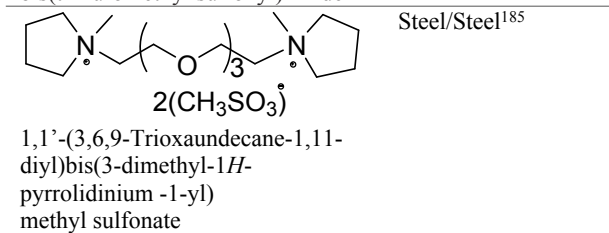
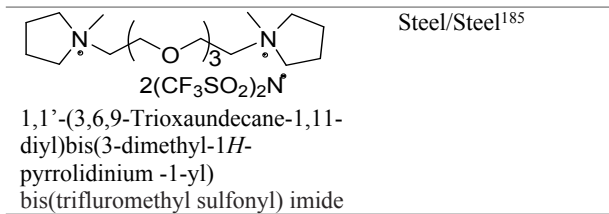
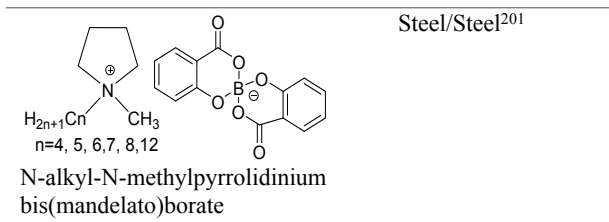
1,1'-(3,6,9-trioxaundecane-1,11-diyl)bis(3-dimethyl-1*H*-imidazolium-1-yl) methyl sulfonates

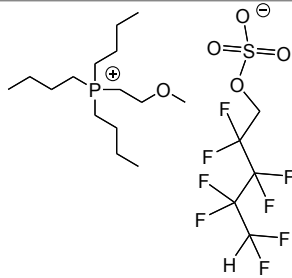


Steel/Steel¹⁸⁵

1,1'-(3,6,9-Trioxaundecane-1,11-diyl)bis(3-dimethyl-1*H*-imidazolium-1-yl) 9
bis(trifluoromethyl sulfonyl)-imide: 1 methyl sulfonates

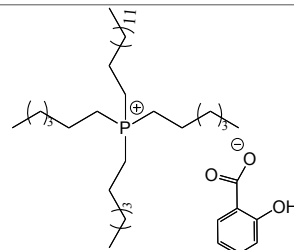






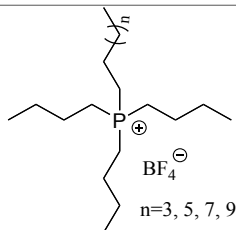
Steel/Steel¹⁷⁹

Tributyl-(2-methoxyethyl)phosphonium 2,2,3,3,4,4,5,5-octa fluoropentyl sulfate



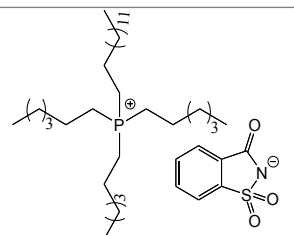
Steel/Al¹¹¹

Trihexyl tetradecylphosphonium Salicylate



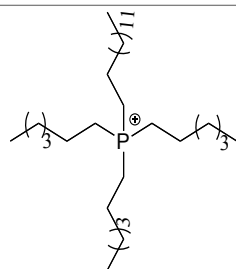
Steel/Steel²⁰⁷,
Steel/Al¹⁵²,
Film³⁴

Tributyltetraalkylphosphonium tetrafluoroborate



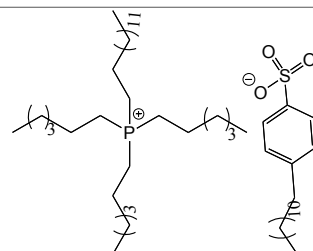
Steel/Al¹¹¹

Trihexyl tetradecylphosphonium saccharinate



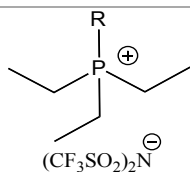
Steel/Steel^{11, 208, 52},
79, 119, 209
Steel/Al^{61, 210-212},
Steel/Polymer²¹³,
Steel/PTFE⁵²

X=Br, (CF₃SO₂)₂N, F₃(C₂F₅)₃P,
BF₄, CH₃(CH₂)₈COO
Trihexyl tetradecylphosphonium
Bromide/bis(trifluoromethyl
sulfonyl)
imide/tris(pentafluoroethyl)trifluoro
phosph/tetrafluoroborate/decanoate



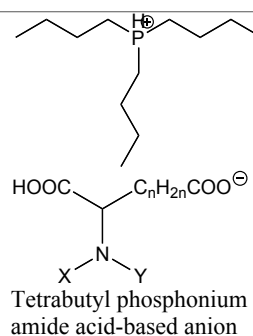
Steel/Steel²⁰⁸

Trihexyl tetradecylphosphonium dodecylbenzenesulfonate



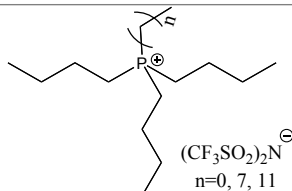
Steel/Steel⁹⁰

R= n-C₅H₁₁, n-C₈H₁₇, n-C₁₂H₂₅,
CH₂C₆H₅, C₂H₄OCH₃
Triethylalkylphosphonium,
bis(trifluoromethyl sulfonyl) imide



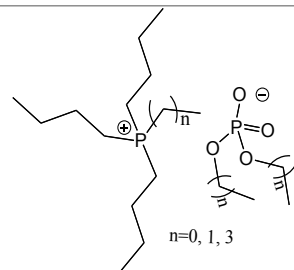
Steel/Steel^{88, 89}

Tetrabutyl phosphonium
amide acid-based anion



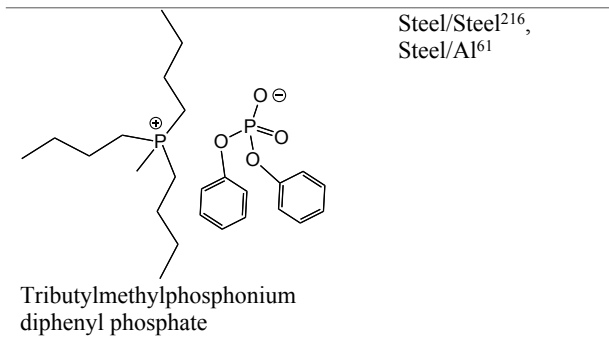
Steel/Steel¹⁰¹

Tributylalkylphosphonium
bis(trifluoromethyl sulfonyl) imide

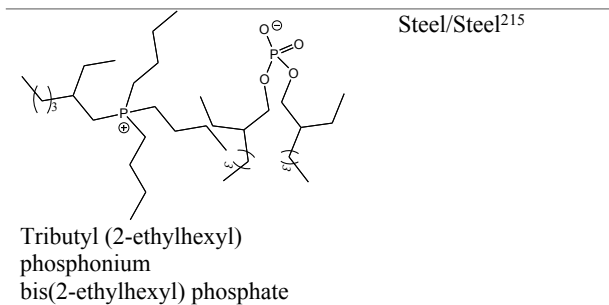


Steel/Steel^{90, 94, 95, 97},
208, 209, 214-216

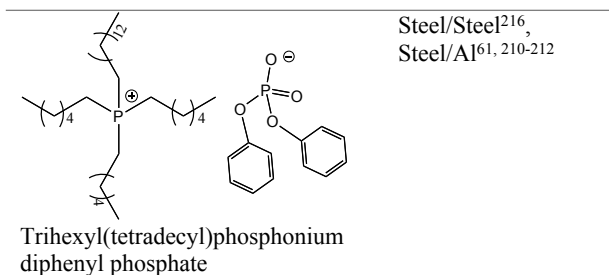
Tributylmethylphosphonium
Dialkylphosphate



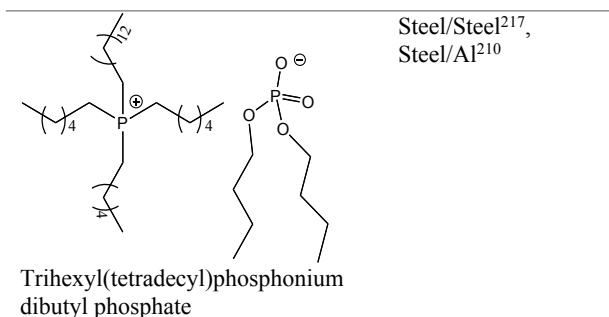
Steel/Steel²¹⁶,
Steel/Al⁶¹



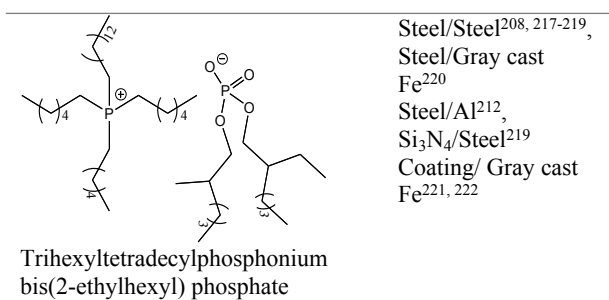
Steel/Steel²¹⁵



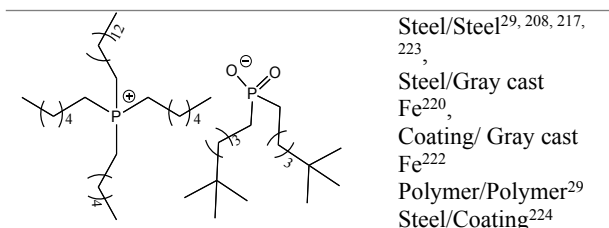
Steel/Steel²¹⁶,
Steel/Al^{61, 210-212}



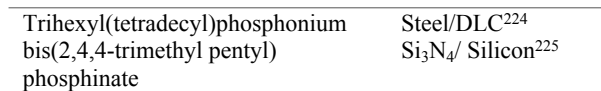
Steel/Steel²¹⁷,
Steel/Al²¹⁰



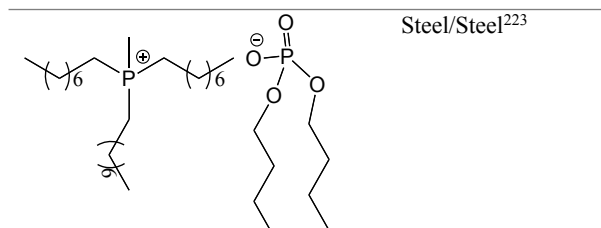
Steel/Steel^{208, 217-219},
Steel/Gray cast
Fe²²⁰
Steel/Al²¹²,
Si₃N₄/Steel²¹⁹
Coating/ Gray cast
Fe^{221, 222}



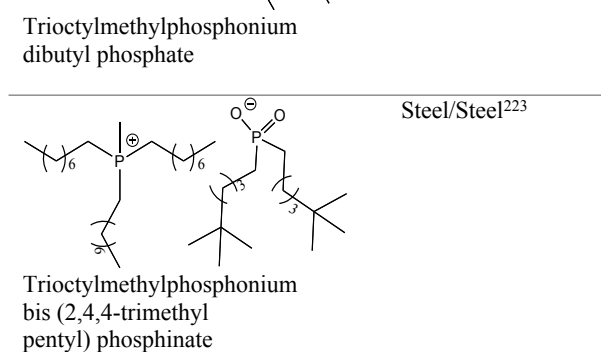
Steel/Steel^{29, 208, 217, 223},
Steel/Gray cast
Fe²²⁰,
Coating/ Gray cast
Fe²²²
Polymer/Polymer²⁹
Steel/Coating²²⁴



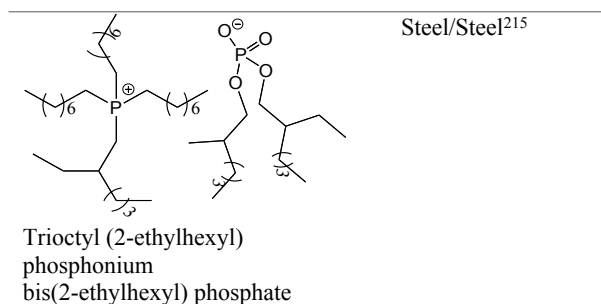
Steel/DLC²²⁴
Si₃N₄/ Silicon²²⁵



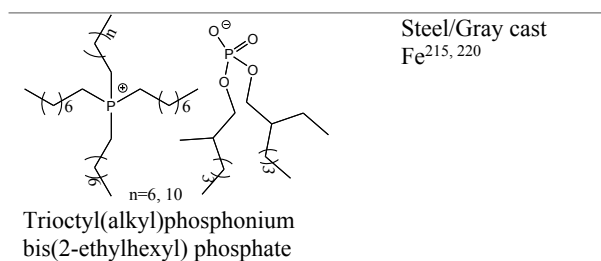
Steel/Steel²²³



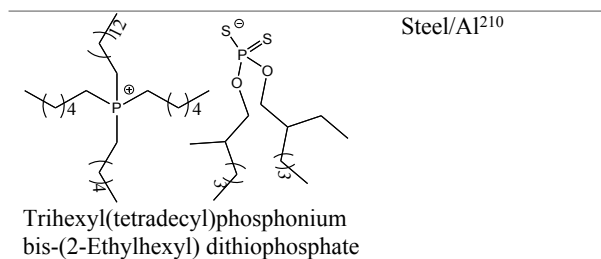
Steel/Steel²²³



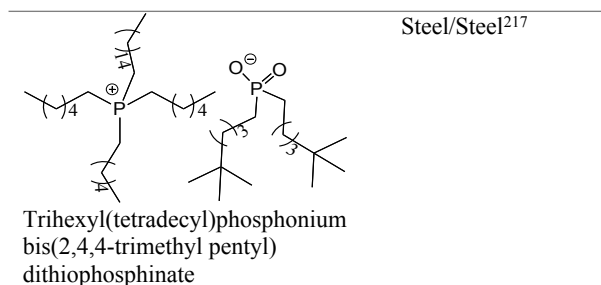
Steel/Steel²¹⁵



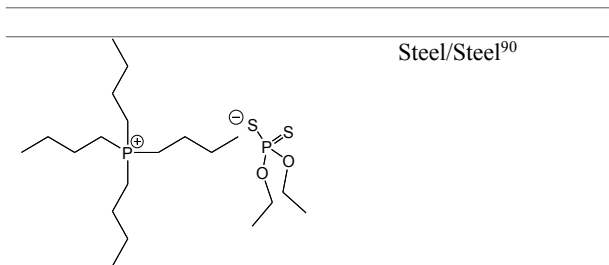
Steel/Gray cast
Fe^{215, 220}



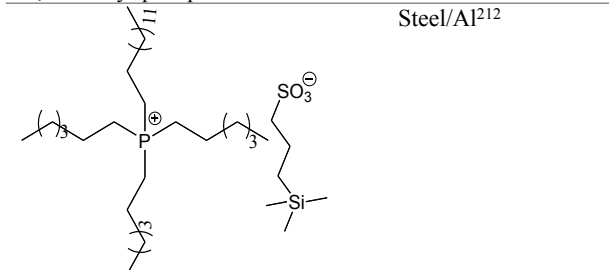
Steel/Al²¹⁰



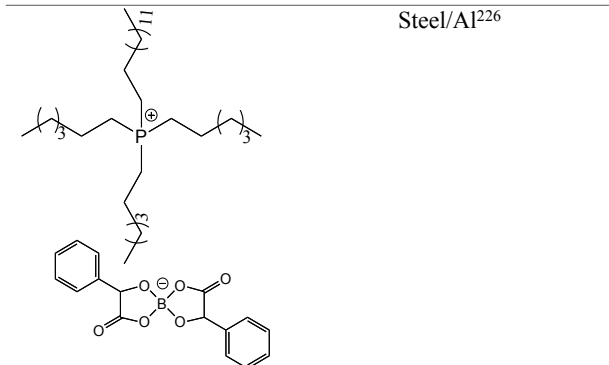
Steel/Steel²¹⁷



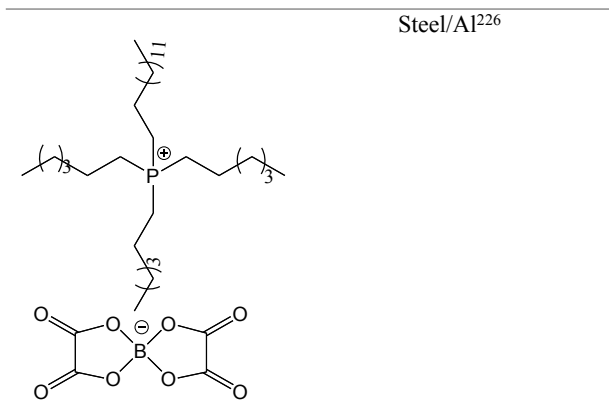
Tetrabutylphosphonium
O,O-diethylphosphorodithioate



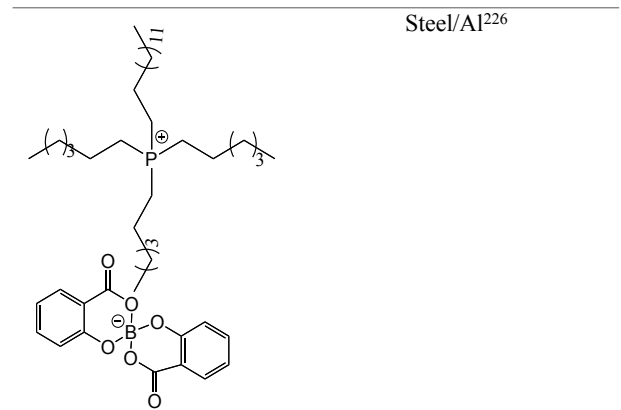
Trihexyl(tetradecyl)phosphonium
3-(trimethylsilyl)propane-1-
sulfonate



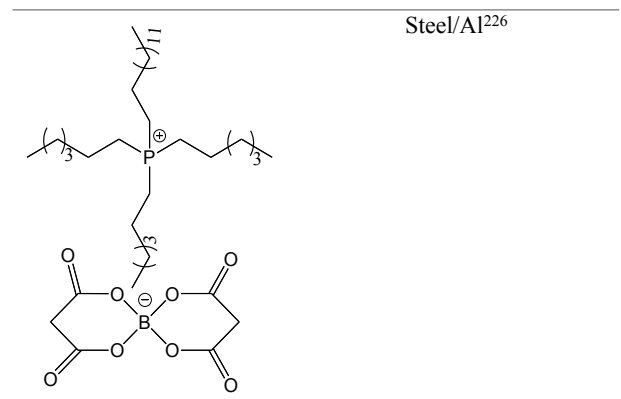
Trihexyl(tetradecyl)phosphonium
bis(mandelato)borate



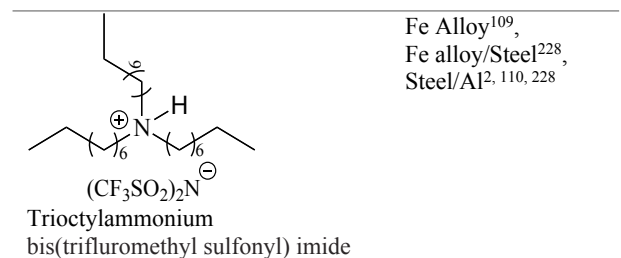
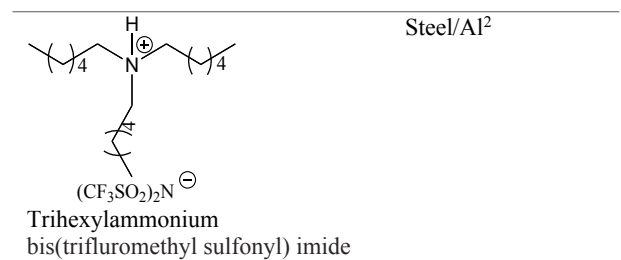
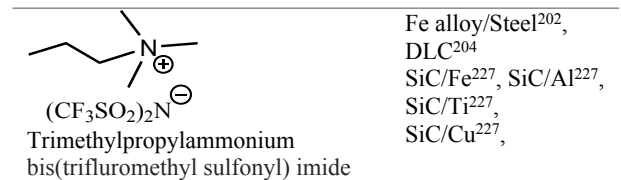
Trihexyl(tetradecyl)phosphonium
bis(oxalato)borate

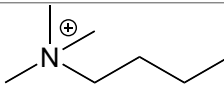
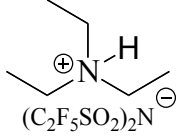
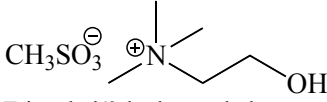
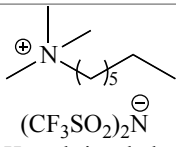
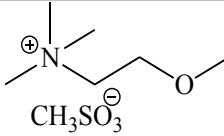
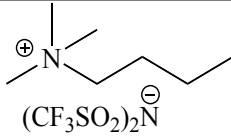
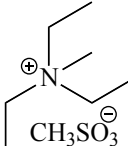
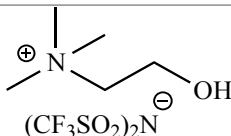
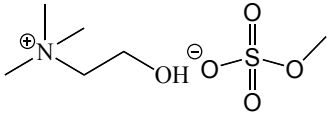
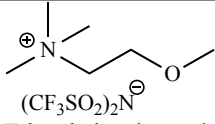
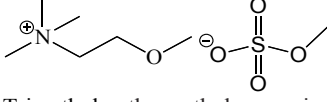
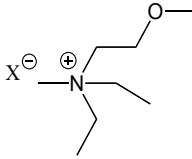
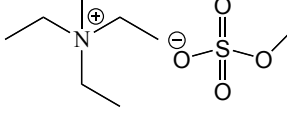
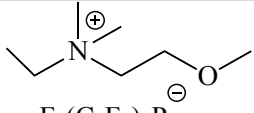
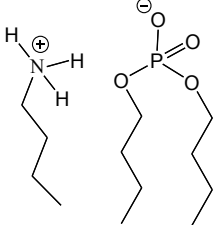
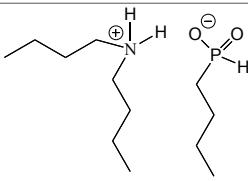


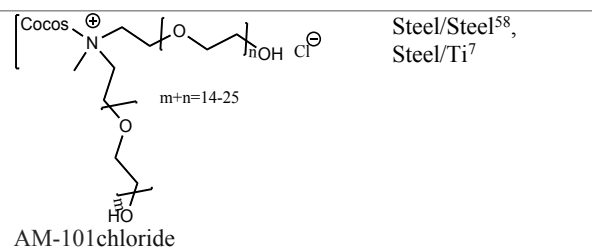
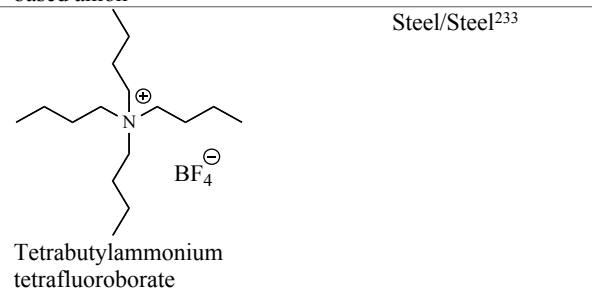
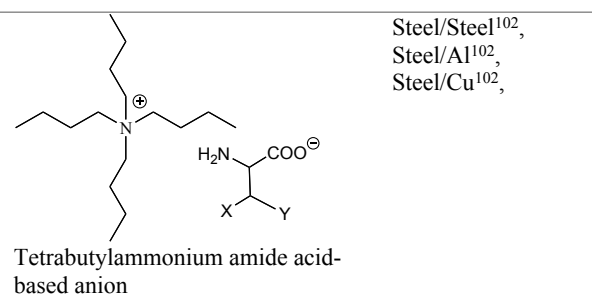
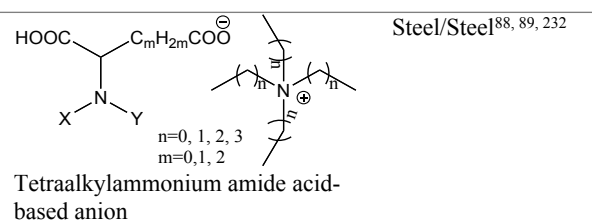
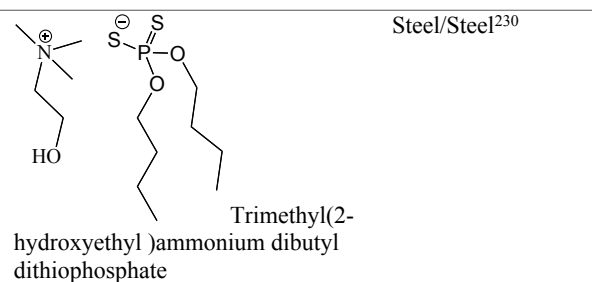
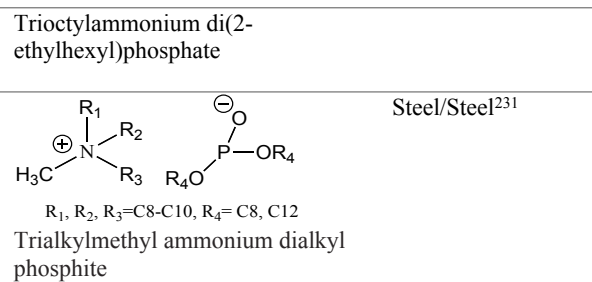
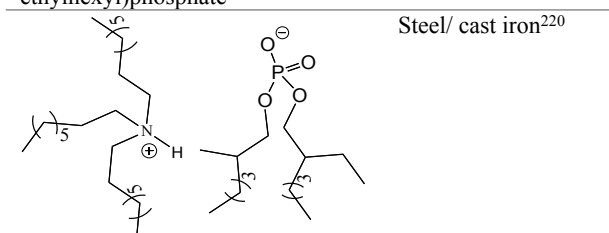
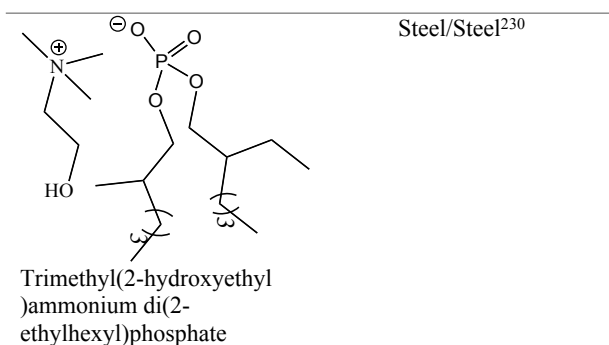
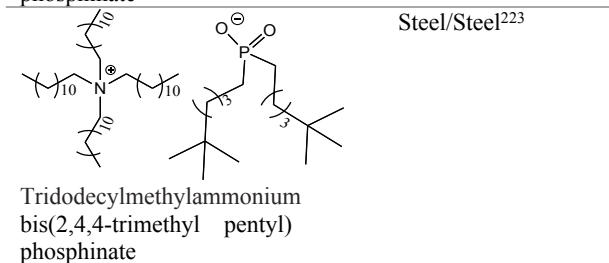
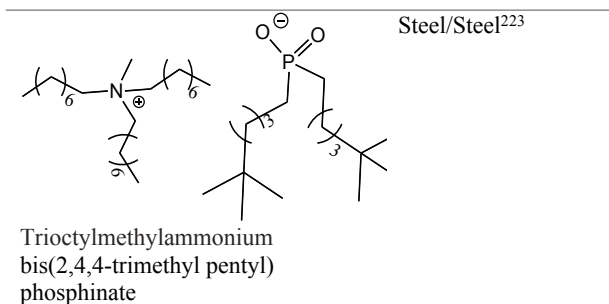
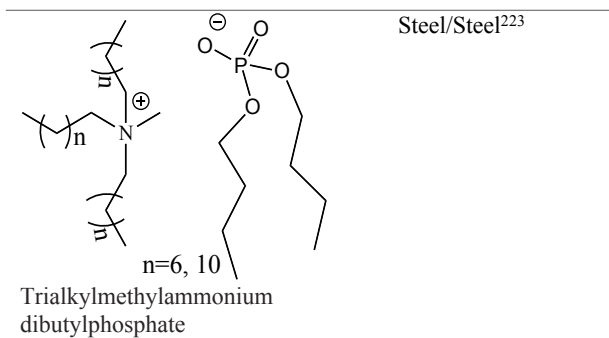
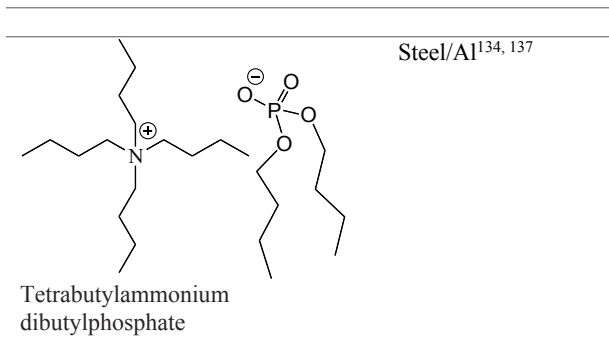
Trihexyl(tetradecyl)phosphonium
bis(silycato)borate

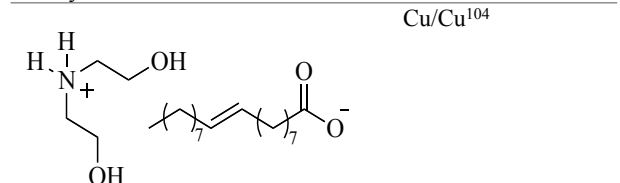
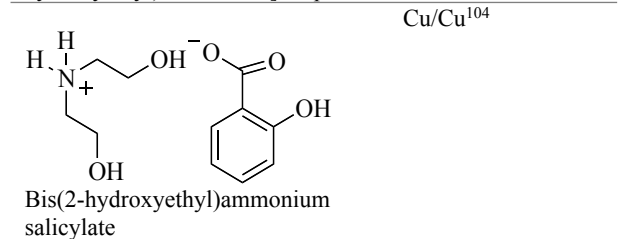
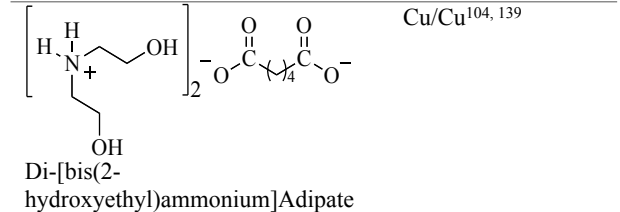
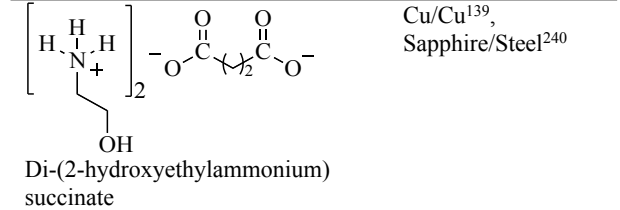
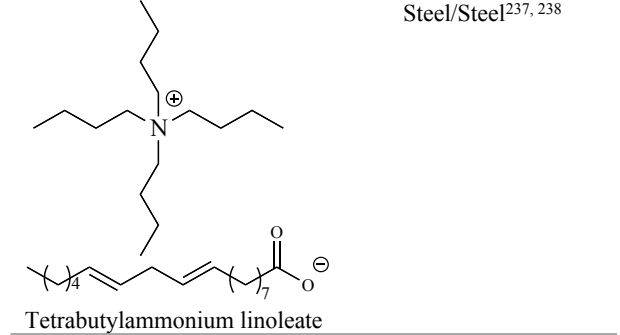
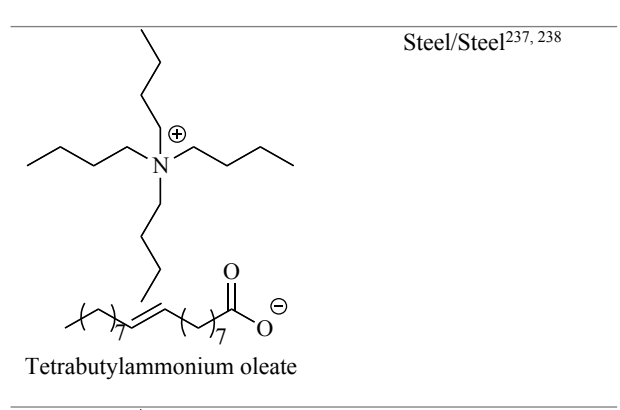
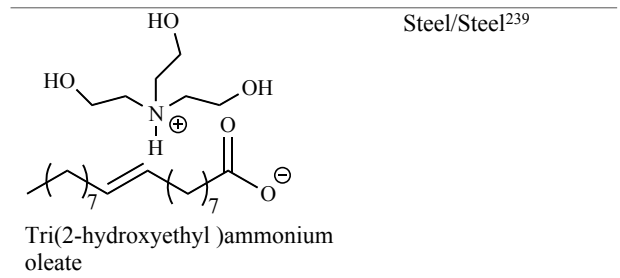
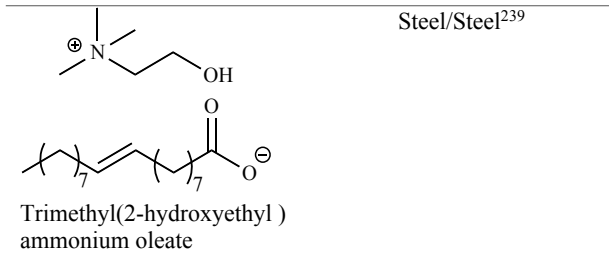
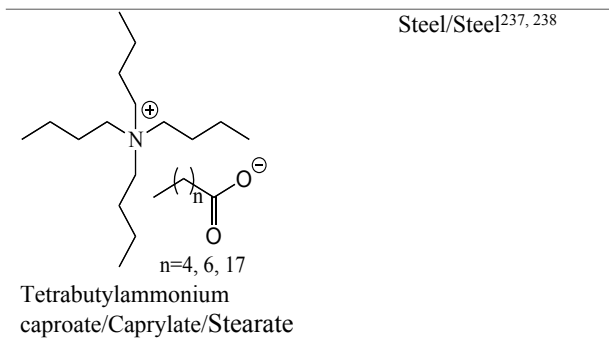
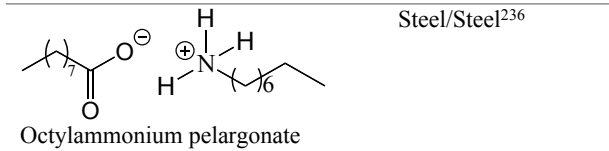
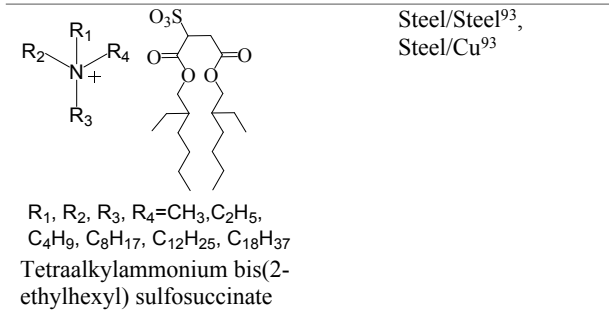
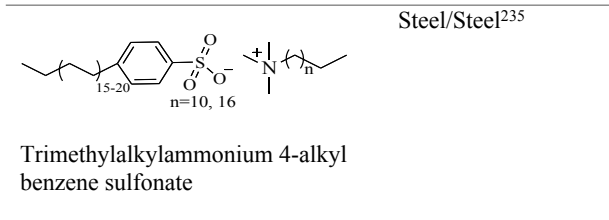
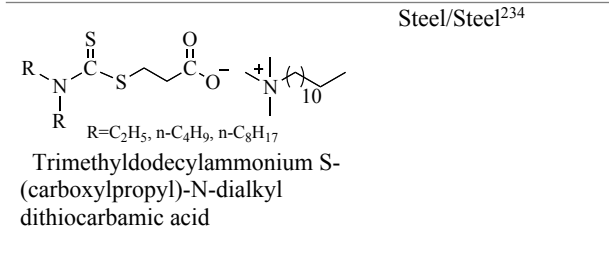
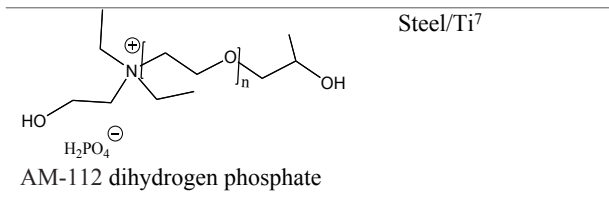


Trihexyl(tetradecyl)phosphonium
bis(malonato)borate

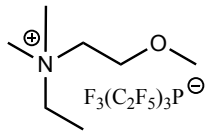


Octadecylammonium bis(trifluoromethyl sulfonyl) imide			Steel/Steel ¹⁷⁶
	Steel/Al ²	CH_3SO_3^- Trimethylbutylammonium methyl sulfonates	
Triethyl ammonium bis(pentafluoroethylsulfonyl)imide)			Steel/Steel ^{176, 195}
	Steel/Steel ¹⁰⁷	CH_3SO_3^- Trimethylmethoxyethylammonium methyl sulfonates	
Heptyltrimethylammonium bis(trifluoromethyl sulfonyl) imide			Steel/Steel ^{176, 195}
	Steel/Steel ^{101, 176}	CH_3SO_3^- Trimethyl(2-hydroxyethyl) ammonium methyl sulfates	
Butyl-trimethylammonium bis(trifluoromethyl sulfonyl) imide			Steel/Steel ¹⁹⁵
	steel/steel ^{176, 193, 195}	CH_3SO_3^- Triethylmethylammonium methyl sulfates	
Trimethyl(2-hydroxyethyl) ammonium bis(trifluoromethyl sulfonyl) imide			Steel/Steel ^{176, 195}
	steel/steel ^{176, 195}	CH_3SO_3^- Trimethyl(2-hydroxyethyl) ammonium methyl sulfate	
Trimethylmethoxyethylammonium bis(trifluoromethyl sulfonyl) imide			Steel/Steel ^{176, 195}
	Steel/Steel ^{24, 88, 90, 195}	CH_3SO_3^- Triethylmethylammonium methyl sulfate	
X=BF ₄ , (CF ₃ SO ₂) ₂ N N,N-diethyl-N-methyl-(2- methoxyethyl) ammonium bis(trifluoromethyl sulfonyl) imide			Steel/Steel ^{176, 195, 196}
	Steel/DLC ²⁰⁰	H^+ Butylammonium dibutylphosphate	
Ethyl-dimethyl-2- methoxyethylammonium tris(pentafluoroethyl) trifluorophosphate			Steel/Al ^{134, 137}
		H^+ N,N-dibutylammonium o- butylphosphate	Steel/Al ^{135, 137}





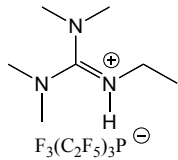
Bis(2-hydroxyethyl)ammonium oleate



Ethyl-dimethyl-2-methoxyethylammonium tris(pentafluoroethyl)trifluorophosphate

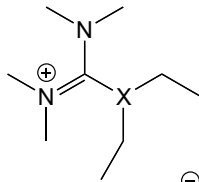
Steel/Steel^{192, 197},
Steel/ CrN coating²⁴¹⁻²⁴³
Steel/ TiN coating^{242, 244}
Steel/DLC²⁴²

Steel/Steel⁷⁹



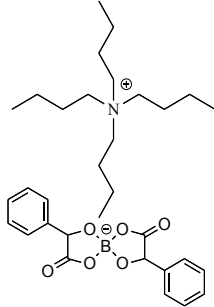
N,N,N',N'-Tetramethyl-N''-Ethylguanidinium tris(pentafluoroethyl)trifluorophosphate

Steel/Steel⁷⁹



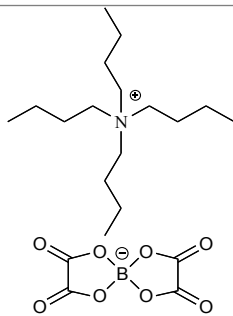
X=O, S F₃(C₂F₅)₃P⁻ X-ethyl-N,N,N',N'-tetramethylisouronium tris(pentafluoroethyl)trifluorophosphate

Steel/Steel²³³



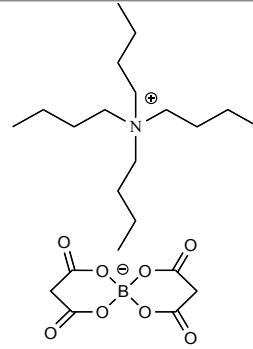
Tetrabutylammonium bis(mandelato)borate

Steel/Steel²³³



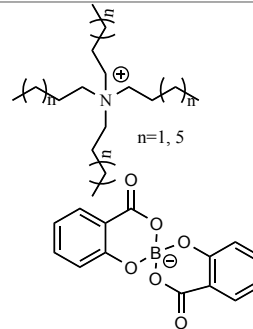
Tetrabutylammonium bis(oxalato)borate

Steel/Steel²³³



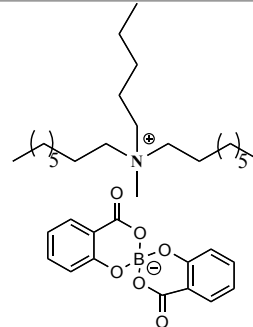
Tetrabutylammonium bis(malonato)borate

Steel/Steel^{182, 233}



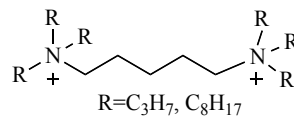
Tetraalkylammonium bis(salicylato)borate

Steel/Steel¹⁸²



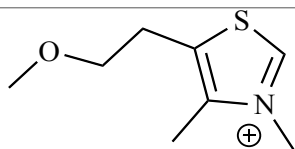
Dioctylmethylpentylammonium bis(salicylato)borate

Steel/Steel¹⁸⁸



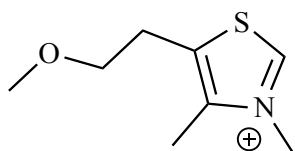
Penta-1,5-diylbis(trialkylammonium) bis(salicylato)borate

AISI 316L/sapphire²⁴⁵
AISI 52100/sapphire²⁴⁵



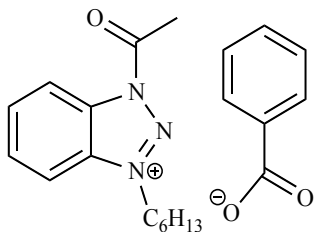
(CN)₂N[⊖]
 5-(2-methoxyethyl)-3,4-
 dimethylthiazol-3-ium
 dicyanamide

AISI
 316L/sapphire²⁴⁵
 AISI
 52100/sapphire²⁴⁵



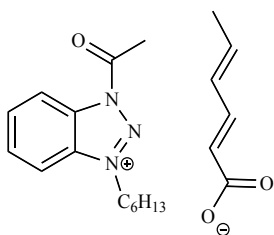
(CF₃SO₃)₂N[⊖]
 5-(2-methoxyethyl)-3,4-
 dimethylthiazol-3-ium
 bis(trifluoromethane sulfonyl)-
 amide

Steel/Al²⁴⁶



1-acetyl-3-hexylbenzotriazolium
 benzoate

Steel/Al²⁴⁶



1-acetyl-3-hexylbenzotriazolium
 sorbate

(denoted as [CmCnim]X, where Cm and Cn are n-
 alkyl chains; im, imidazolium; X, counteranion)

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