

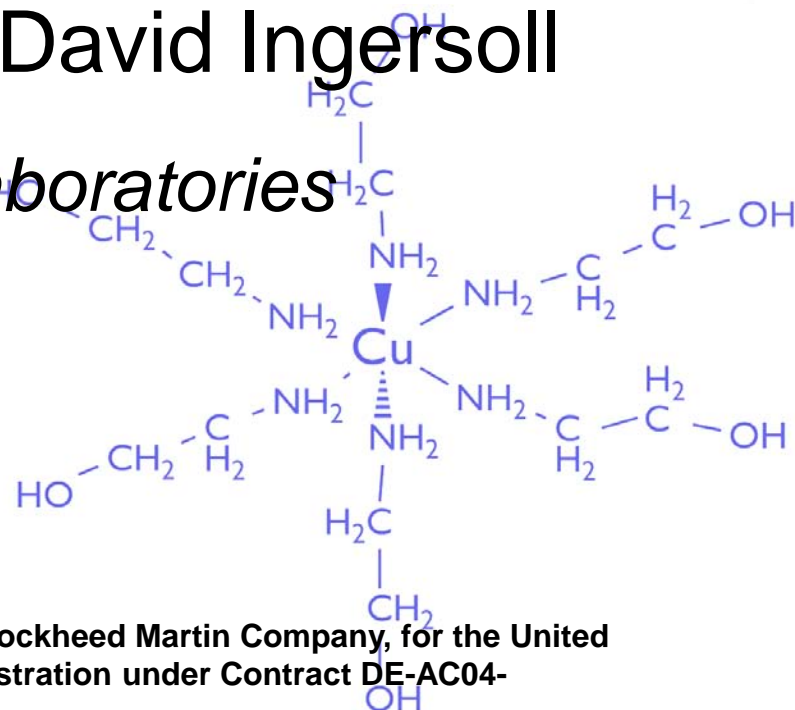


# MetILs: New Ionic Liquids for Flow Batteries



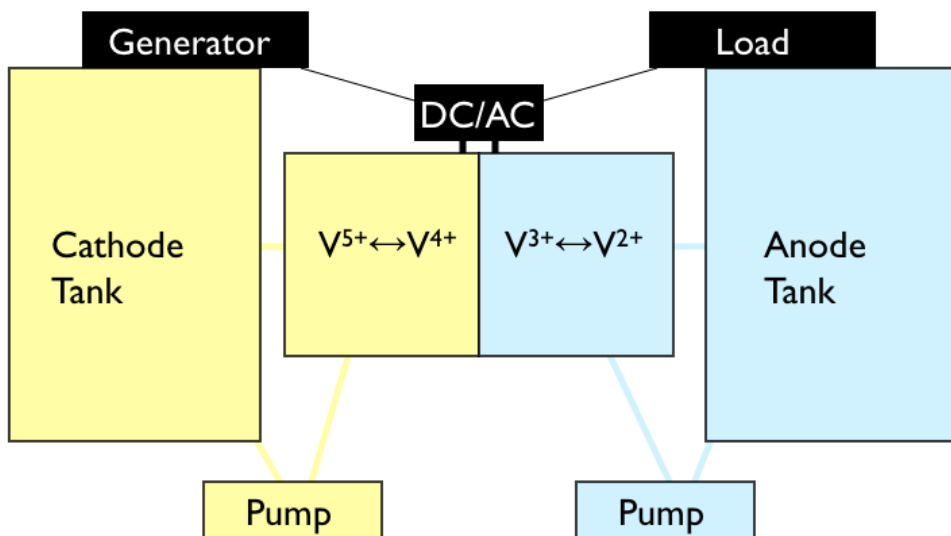
Travis M. Anderson and David Ingersoll

*Sandia National Laboratories*

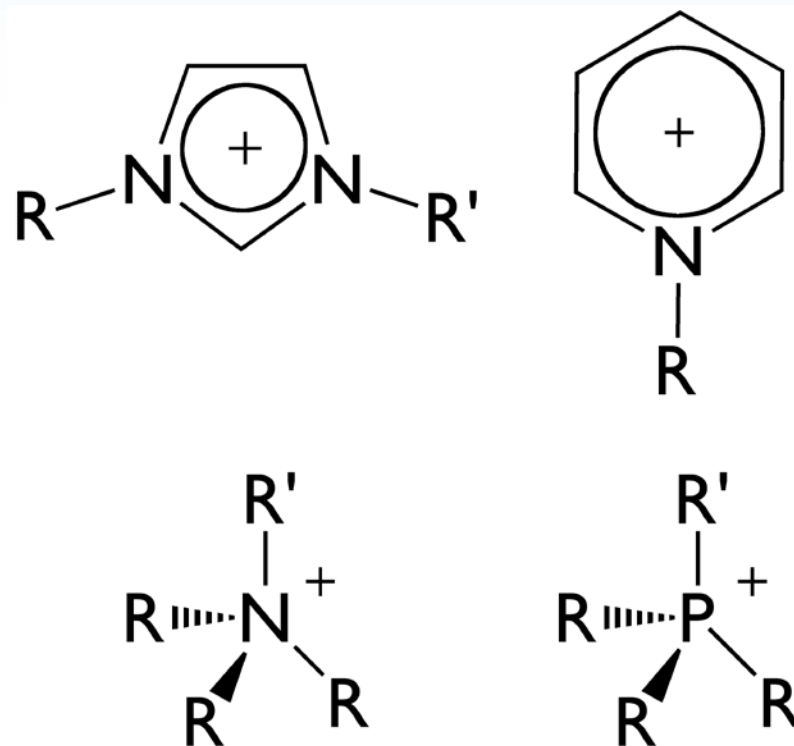


Sandia National Laboratories is a multiprogram Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

# Ionic Liquids (ILs) for Flow Batteries

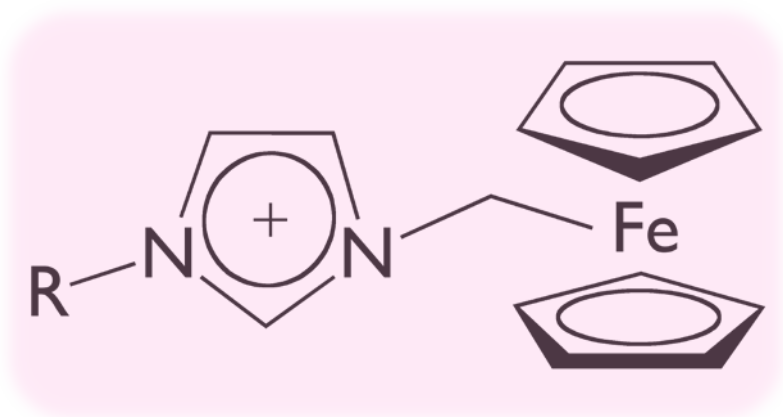


- Higher energy density
- Negligible vapor pressure
- Non-corrosive

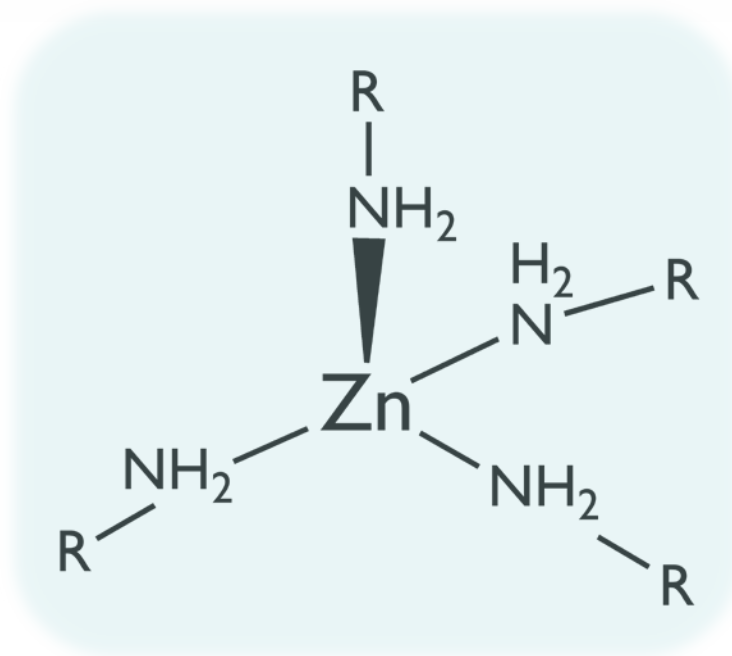


- Low symmetry
- Weak Intermolecular Forces
- Low charge density

# Ionic Liquids with Metal Cations (MetILs)



**Ferrocenyl-Functionalized  
Imidazoliums**

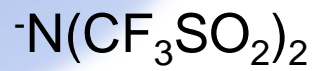


**Zinc- and Silver-Amine  
Complexes**

# Initial Strategy to MetILs



2+



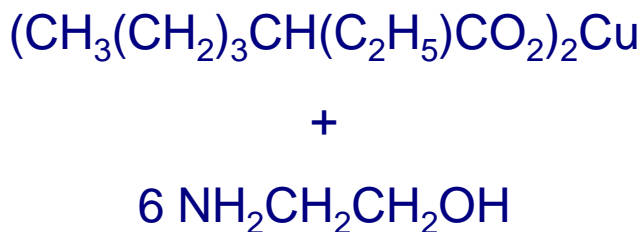
2+



**Modify the surface of the coordination sphere with new functional groups**

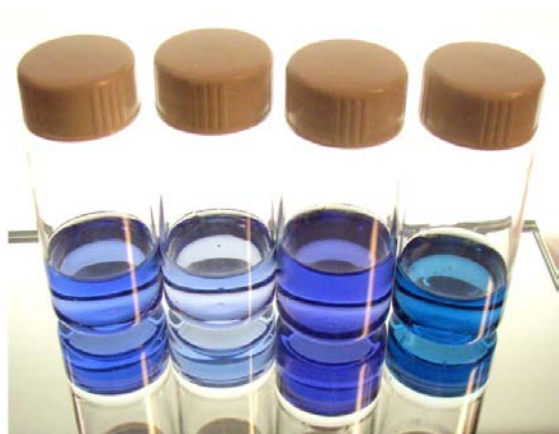
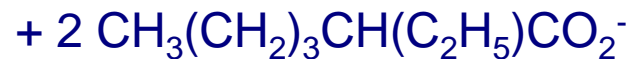
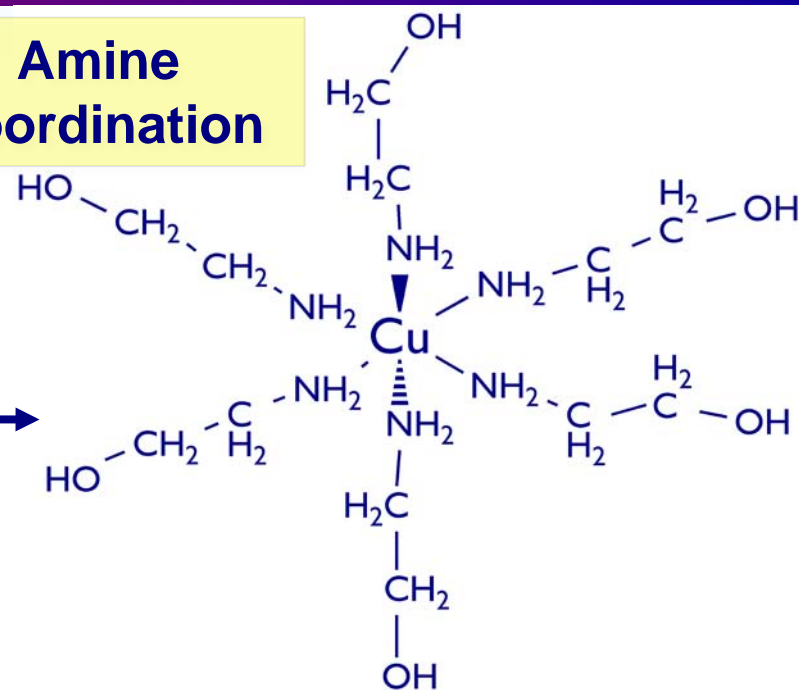


# FY09 Activities



115°C, 5 min

**Amine  
Coordination**

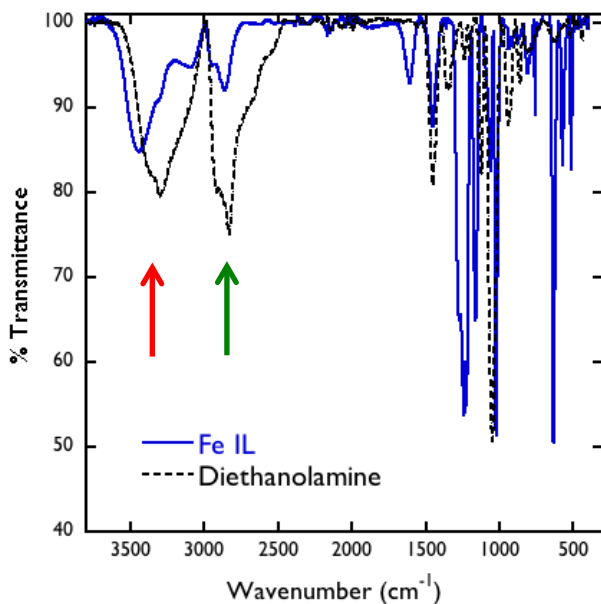
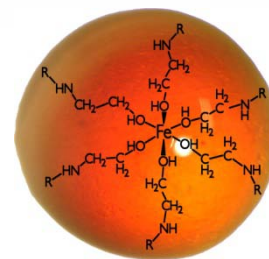


## Synthesis Properties

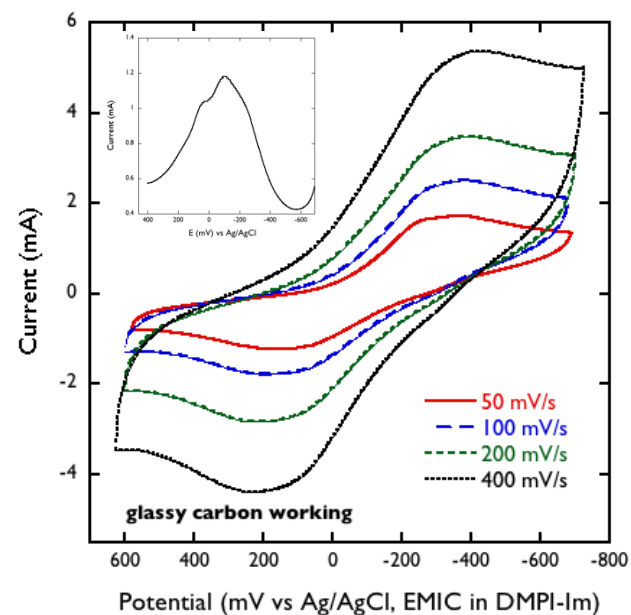
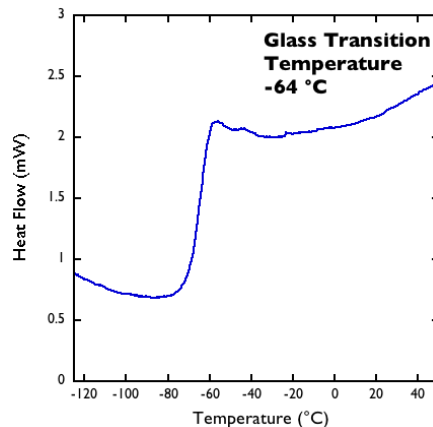
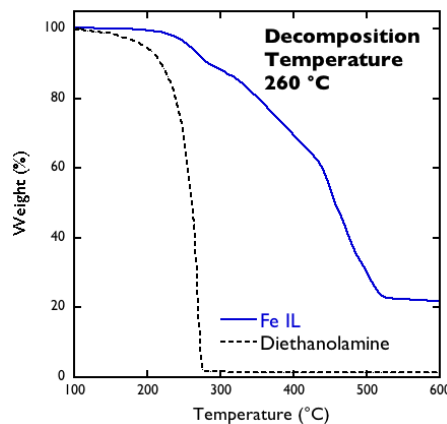
- Scalable
- Large Versatility
- Low Cost

# FY10: Synthesis of an iron ionic liquid

Anderson, Ingersoll, Rose, Staiger, and Leonard, *Dalton Trans.* **2010**, 8609–8612.



Hydroxyl ( $\uparrow$ ) and amine bands ( $\uparrow$ ) of Fe IL are blue shifted 200 and 30  $\text{cm}^{-1}$  relative to diethanolamine.



$$\sigma = 0.207 \text{ mS cm}^{-1}$$

$$\mu = 4482 \text{ cP}$$

# FY10: MetILs Family

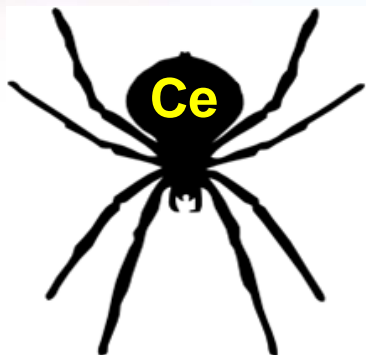
Versatile synthesis allows one to tailor material and electrochemical properties



	Mn-1	Mn-2	Fe-1	Fe-2	Zn-1	Zn-2	Zn-3	Cu-1	Cu-2	Cu-3	Cu-4
$\mu$ [cP]	11671	760	6413	4482	2533	7957	1585	3383	12313	1295	5028
$\sigma$ [mS cm <sup>-1</sup> ]	624	0.45	466	0.21	0.34	0.10	439	0.05	0.01	0.07	0.01
T <sub>g</sub> [°C]	-52	-82	-70	-64	-84	-55	-52	-63	-54	-65	-53
T <sub>d</sub> [°C]	260	215	290	260	150	150	200	190	230	240	255
OH/NH*	NH	NH	OH	OH	OH	OH	**	NH	OH	NH	NH

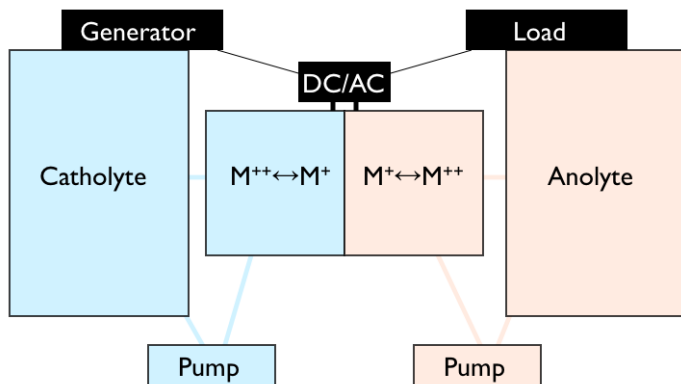
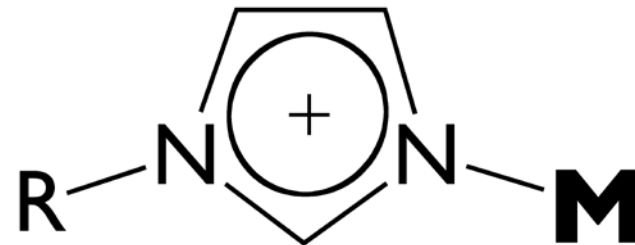
\*OH, hydroxyl coordination, NH amine coordination \*\*no preference

# FY11 Planning



Recent work with cerium has yielded a “spider” IL with significantly lower viscosity and higher conductivity.

Experiment with new metals (Ce, V, and Co), new ligands (Im), and new anions (NTf<sub>2</sub>)



Build flow battery tester designed to accommodate ILs





# Acknowledgements

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