

# The CONTACTOR™

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## Amine Strength & Temperature

Have you ever wondered about the best amine strength for a given application? Or whether you should use a colder or a hotter lean amine temperature? You're not alone, but the right answers can be hard to come by, especially if you're using a simulation tool based on theoretical stages instead of *ProTreat*™.

The prevalence of sour gas has forced many of us to focus on *selective* removal of H<sub>2</sub>S from gases containing CO<sub>2</sub>, usually using MDEA. The objectives vary from slipping or rejecting as much CO<sub>2</sub> as possible to perhaps meeting a high-concentration CO<sub>2</sub> specification. In these kinds of applications, the experience of a number of engineers is that high-strength solvents at higher temperatures are better at rejecting CO<sub>2</sub>. Then when we are faced with removing CO<sub>2</sub> from sweet gas, the same tricks don't work. In fact, they may have the opposite effect, and we wonder why. This issue of *The Contactor* addresses the basic differences between CO<sub>2</sub> removal and CO<sub>2</sub> rejection, and why strategies that work well in achieving one set of objectives, may produce the opposite effect under contrary circumstances. The result is some guidelines for achieving CO<sub>2</sub> treating goals.

### Case 1: Selective Treating of a Sour Gas

Selective treating is most often done using generic MDEA. In this example we look at the way absorber performance is affected by MDEA strength at constant lean loadings (0.001 H<sub>2</sub>S, 0.0002 CO<sub>2</sub>) and 100°F. One of the serious challenges to really understanding the effect of process parameters on gas treating is being able to deal with the fact that rarely can only one parameter be change without affecting others. In this example, the gas to be treated is at 80°F and 900 psig and contains 5% CO<sub>2</sub> and 2% H<sub>2</sub>S. We are interested in the effect of solvent strength (wt% MDEA) on treating. However, when the solvent

strength is increased from 30 wt% to 50 wt%, for example, and all other parameters are kept constant, the solvent capacity becomes under utilized. In other words, more than one thing is being changed at a time, making it harder to segregate the effect of one parameter from another. We will take a more pragmatic view and simply ask "How does the solvent flow needed to achieve 4 ppmv H<sub>2</sub>S depend on amine strength? And how does CO<sub>2</sub> removal then change?"

For this 20-tray column, Figure 1 shows several interesting behaviors. First, in terms of using minimum solvent flow, there is an optimal amine strength of 45 wt% MDEA to achieve 4 ppmv H<sub>2</sub>S in the treated gas. This happens to require a solvent flow rate of about 430 gpm and it leaves about 2.5% CO<sub>2</sub> in the treated gas.

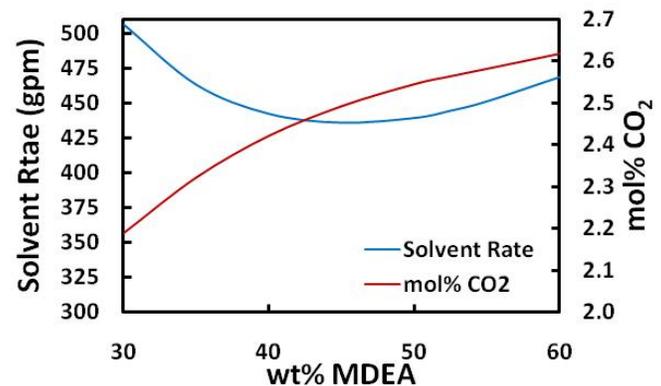
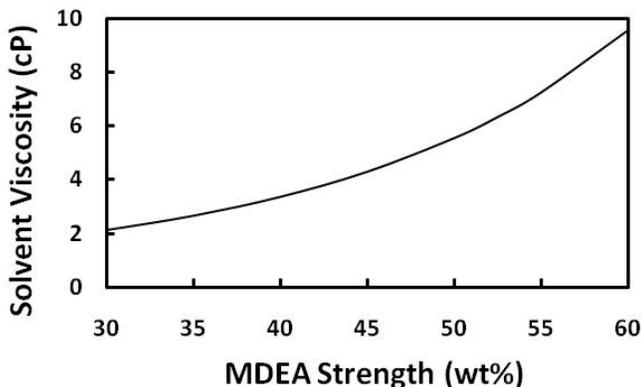


Figure 1 Effect of Amine Strength on Performance in Example 1

Of greater interest to us here, however, is the fact that as the MDEA strength is *increased*, the amount of CO<sub>2</sub> absorbed *decreases* significantly. This is somewhat surprising on at least two counts: (1) doubling the amine strength from 30 to 60 wt% doubles the solvent capacity so the solvent should be able to hold more CO<sub>2</sub>, and (2) doubling the amine concentration should double the CO<sub>2</sub>

reaction rate with the amine in the solvent. *Both factors should cause more CO<sub>2</sub> absorption*, not less. This strongly suggests that CO<sub>2</sub>-MDEA reaction kinetics is not important in determining absorption rates, so long as the reaction is fast enough for the CO<sub>2</sub> to convert fully to bicarbonate in the bulk solvent. This is very much in line with the conclusions reached in an earlier issue of *The Contactor* (Volume 4, Issue 3, 2009). The absorption rate of CO<sub>2</sub> into MDEA is not reaction-kinetics controlled. It is controlled strictly by the resistance to mass transfer in the solvent phase. If your simulation tool ignores mass transfer resistances (and, no matter how embellished, all equilibrium stage models do), it is inadequate for truly reliable design.

The factor responsible for poorer CO<sub>2</sub> absorption at high MDEA strength is solution viscosity. As Figure 2 shows, at 100°F a 60 wt% unloaded MDEA solution is five times more viscous than it is at 30 wt%. The high viscosity makes it harder to agitate, greatly increasing the resistance to CO<sub>2</sub> transfer through the liquid.



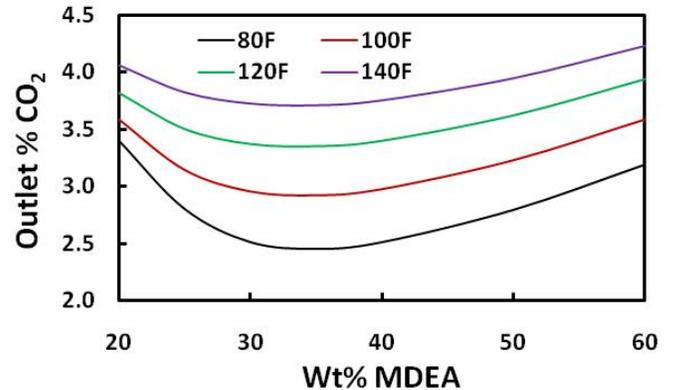
**Figure 2 Effect of MDEA Strength on Viscosity at 100°F**

**Case 2: CO<sub>2</sub> Removal from a Sweet Gas**

The conditions for this example are the same as for Case 1 with the exception that the gas is 7% CO<sub>2</sub> and it is sweet. The question being asked here is, “What effect does MDEA strength have on CO<sub>2</sub> removal and how is that impacted by solvent temperature?” The same 20-tray column is being used to treat with 500 gpm of MDEA at various concentrations and temperatures. Figure 2 shows how CO<sub>2</sub> removal performance responds to these two process parameters.

Unlike the selective removal case, here we see that almost regardless of temperature, CO<sub>2</sub> removal is maximized with 35 wt% MDEA solvent.

If too low an amine strength is used, the solvent flow becomes the limiting factor. In other words solvent capacity restricts performance and further reducing amine strength worsens the limitation. On the other side of 35 wt%, however, the same factor that was at play in Case 1 is also working here. Higher solvent viscosity increases mass transfer resistance, and because CO<sub>2</sub> absorption is controlled by mass transfer in the liquid phase, more and more CO<sub>2</sub> slips from the column.



**Figure 3 Effect of MDEA Strength and Temperature on CO<sub>2</sub> Removal**

At higher temperatures, of course, solution viscosity is lowered but a parameter more responsive to temperature is the equilibrium partial pressure of CO<sub>2</sub> over the loaded solution. A hotter solution has higher CO<sub>2</sub> vapor pressures, so the driving force for absorption, hence the absorption rate, are lower. Thus the amount of CO<sub>2</sub> absorbed, is lower too. But the negative effect of solvent viscosity remains, regardless of the temperature.

These examples are intended to indicate that maybe 50 wt% MDEA isn't always the best choice. They also try to point out that solvent viscosity can play an important role in both selective treating and bulk CO<sub>2</sub> removal. The numerical values pertain to the specific examples and should not be construed as having general validity. Nonetheless, viscosity is an important property, and outside pressure drop calculations, it is accounted for only by *ProTreat*<sup>™</sup> simulation.

To learn more about this and other aspects of gas treating, plan to attend one of our workshops in Houston, Baden-Baden, Doha, or Abu Dhabi in 2011-12. Visit [www.oqtr.com/seminars](http://www.oqtr.com/seminars) for details.

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