Comparison of novel urease inhibitors to reduce ammonia emissions under laboratory conditions
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Abstract
The experiments were conducted under laboratory conditions at substratum temperatures of 5 °C, 15 °C and 25 °C. In general, the four novel urease inhibitors showed a reduction of urea breakdown and therefore also of the ammonia release, but on different reduction levels. By the use of one novel urease inhibitor (type D) an explicit higher reduction of the ammonia release as by the use of the well-known NBTPT inhibitor was obtained.

Both the commercially available NBTPT inhibitor and the novel urease inhibitor type D reduced the ammonia release of slurry of different sources (farms) with again a better reduction effectivity of the novel inhibitor type D compared to NBTPT.

Key words: ammonia emission, urease, urease inhibitors

Introduction and objectives
Cattle husbandry is the main source of agricultural ammonia emissions. The major part of these ammonia emissions is released from cattle houses. Thus especially strategies to cut the ammonia release on housing level promise to be very effective to lower the emissions [1, 2]. Therefore the aim of this research project is to test the effectiveness of different novel urease inhibitors in order to reduce the urea breakdown, ammonia emissions from animal facilities respectively and to compare their reduction potential to the commercially available urease inhibitor N-(n-butyl) thiophosphoric triamide (NBTPT) [3]. A standardised laboratory measuring system is used to detect the inhibitor with the best reduction potential and to study the dose-effect relationships of the inhibitor under laboratory conditions.

Material and methods
In order to obtain reproducible and controllable conditions the experiments were conducted with a specific standardised laboratory measuring system (figure 1). This measuring system allows to quantify the effect of urease inhibitors on the level of the urea breakdown and the
ammonia release respectively from slurry after addition of certain amounts of artificial urea at different treatments within the frame of serial and parallel experiments which were arranged randomised.

Figure 1: Sketch of the standardised laboratory measuring system (altogether 28 glass bottles)

The standardised measuring system works according to the principle of a dynamic chamber and consists of 28 glass bottles (5 l) which are filled with 2 litre slurry of dairy cows. The glass bottles are arranged in a temperature controlled water bath, so that the temperature of the substratum (slurry) can be adjusted similar to different temperature conditions. The concentration of the applied urease inhibitor solution is based on the Total-Kjeldahl-Nitrogen (TKN) content of the slurry. After application of the urease inhibitor solution (100 ml) artificial urea solution (100 ml per application, e.g. concentration: 20 g urea/l) will be added four times in regular intervals of 24 hours. The ammonia release from each bottle is measured by means of NDIR-spectroscopy continuous over 96 hours. Two special treatments A and B without inhibitor applied are done for comparing reasons. Treatment A serves to show the natural release of ammonia from the slurry by adding only water instead of urea solution. Treatment B is designed to receive the (not influenced) release of ammonia from the slurry after artificial urea solution is applied but no inhibitor and just the same amount of water
instead to establish comparable moisture conditions (treatment B). Per treatment several repetitions (4 glass bottles per treatment) are randomly arranged.

Altogether four different novel urease inhibitors were tested and compared to the commercially available inhibitor NBPT (urease inhibitor type C). The urease inhibitors were tested at substratum temperatures of 5 °C, 15 °C and 25 °C and at urease inhibitor concentrations between 0.0001% and 1% of Total Kjeldahl Nitrogen (TKN) (table 1).

Table 1: Summary of the treatments and urease inhibitor concentrations for the comparison of the effectiveness of different urease inhibitors

<table>
<thead>
<tr>
<th>treatment</th>
<th>group of urease inhibitor concentration</th>
<th>urease inhibitor concentration (average) [% of TKN]</th>
<th>application of urease inhibitor solution (UIS) [100 ml]</th>
<th>1. application of urea solution (US) direct after addition of UIS [100 ml]</th>
<th>2. application of urea solution (US) 24 h after addition of UIS [100 ml]</th>
<th>3. application of urea solution (US) 48 h after addition of UIS [100 ml]</th>
<th>4. application of urea solution (US) 72 h after addition of UIS [100 ml]</th>
<th>end of measuring 96 h after application of UIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>H_{2}O</td>
<td>H_{2}O</td>
<td>H_{2}O</td>
<td>H_{2}O</td>
<td>H_{2}O</td>
<td>H_{2}O</td>
<td>96 h after application of UIS</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>H_{2}O</td>
<td>US</td>
<td>US</td>
<td>US</td>
<td>US</td>
<td>US</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>0.01</td>
<td>UIS</td>
<td>US</td>
<td>US</td>
<td>US</td>
<td>US</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>0.0001</td>
<td>UIS</td>
<td>US</td>
<td>US</td>
<td>US</td>
<td>US</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>2</td>
<td>0.01</td>
<td>UIS</td>
<td>US</td>
<td>US</td>
<td>US</td>
<td>US</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>2</td>
<td>0.001</td>
<td>UIS</td>
<td>US</td>
<td>US</td>
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<td>US</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>3</td>
<td>0.01</td>
<td>UIS</td>
<td>US</td>
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<td>US</td>
<td>US</td>
<td></td>
</tr>
</tbody>
</table>

Selected preliminary results
The effect of the ammonia release depends on the temperature of substratum, the type of urease inhibitor and the applied concentration of the particular urease inhibitor (figure 2). Within a treatment most of ammonia is released at a substratum temperature of 25 °C, whereas at a substratum temperature of 5 °C the release of ammonia is clearly lower. At the
same substratum temperature the urease inhibitors showed a clear dose-effect relationship: the higher the applied urease inhibitor concentration the lower was the detected ammonia release (with exception of urease inhibitor G).

Figure 2: Cumulative Ammonia release over 96 hours in dependence of the application of different urease inhibitors (C, D, E, F and G) in different concentration classes (1 to 4) and at different substratum temperatures (5 °C, 15 °C, 25 °C).

The best reduction effect of the ammonia release shows the treatment D4 with the urease inhibitor type D at a applied concentration of about 0.1% of TKN and at substratum temperatures of 5 °C and 15 °C; the treatment with this inhibitor is statisticly not different from the low natural emission of comparison treatment A without urea applied (Student-Newman-Keuls-Test). At a substratum temperature of 25 °C the ammonia release of treatment D4 is higher than the natural release (treatment A) but still the effect of reduction of the ammonia release is at this temperature the best of all inhibitors after all. In comparison to

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**Table 1:**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>A</th>
<th>B</th>
<th>C3</th>
<th>C4</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>E4</th>
<th>F4</th>
<th>G4</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 °C (n)</td>
<td>29</td>
<td>29</td>
<td>12</td>
<td>25</td>
<td>4</td>
<td>16</td>
<td>20</td>
<td>17</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>15 °C (n)</td>
<td>64</td>
<td>62</td>
<td>20</td>
<td>38</td>
<td>8</td>
<td>36</td>
<td>52</td>
<td>49</td>
<td>8</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>25 °C (n)</td>
<td>33</td>
<td>33</td>
<td>12</td>
<td>35</td>
<td>4</td>
<td>16</td>
<td>20</td>
<td>27</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

1) treatment A: without urease inhibitor and urea (only water)  
2) group 1: 0.0001% of Total Kjeldahl Nitrogen (TKN)  
   group 2: 0.001% of Total Kjeldahl Nitrogen (TKN)  
   group 3: 0.01% of Total Kjeldahl Nitrogen (TKN)  
   group 4: 0.1% of Total Kjeldahl Nitrogen (TKN)
the inhibitor NBTPT (urease inhibitor type C) the urease inhibitor type D shows a distinct higher reduction effect of ammonia release at substratum temperatures of 15 °C and 25 °C.

The effectiveness of the inhibitor NBTPT and the novel urease inhibitor type D both in concentration of 0,1% of TKN was tested also for urea applied on slurry of two different origins/cattle farms at substratum temperatures of 5 °C, 15 °C and 25 °C (figure 3).

![Figure 3: Effectiveness of urease inhibitors NBTPT and type D for slurries on the cumulated ammonia release over 96 h for two different slurry origins and at different substratum temperatures (inhibitor concentration 0,1% of TKN each).](image)

The release of ammonia from untreated slurry (treatment B) of 2 origins/farms were different. For example: at a substratum temperature of 15 °C the ammonia release from the slurry of farm 2 was about twofold higher as from the slurry of farm 1. But nevertheless both urease inhibitors were able to reduce the ammonia release as far as possible independent of the origin (resp. ammonia release potential) of the slurry. The ammonia release by the treatment with the urease inhibitor NBTPT (urease inhibitor type C) was always higher (5g/m²) as by the treatment with the novel urease inhibitor type D (1g/m²) resulting in lower reduction potential of inhibitor C then D. At substratum temperatures of 5 °C and 25 °C the urease inhibitor type D shows a lower sensitivity with respect to different slurry origins ammonia release potentials respectively as the NBTPT inhibitor.
Conclusion and perspective
Under laboratory conditions the novel urease inhibitor type D was detected as the inhibitor with the best reduction potential. The sensitivity of this inhibitor to reduce the ammonia release from urea applied on cattle slurry from different origin, with different contents respect. is lower then of the urease inhibitor NBTPT (urease inhibitor type C). Therefore urease inhibitor type D was selected to be further tested under practical farm conditions

References

