TITRATION SYSTEMS AND
DETECTION SYSTEMS

Figure 2 plots relative standard uncertainties for the different titration systems evaluated, where it is observed that the uncertainties of the gravimetric methods present, in general, a decrease of 40% with respect to the volumetric titration. These differences are attributed to the better metrological characteristics of the mass instruments as compared to those of volumetric.

**Experimental Acid-base Titration**

The mathematical model that is proposed for the determination of the concentration of NaOH through the primary reference method (PRM), is given by the following equation:

\[ C_{NaOH} = \frac{W_{t, end} - W_{t, start}}{V_{Titrant} \times 1000} R \]

Table 1 presents the main sources of uncertainty measurement with the expression used for the estimation.

<table>
<thead>
<tr>
<th>Uncertainty Source</th>
<th>Expression for the Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (mM)</td>
<td>( m_{\text{weight}} = \frac{m_{\text{sample}}}{\sqrt{\text{bias}^2 + \text{uncertainty}^2}} )</td>
</tr>
<tr>
<td>Molecular mass (mM)</td>
<td>( m_{\text{mass}} = \frac{m_{\text{sample}}}{\sqrt{\text{bias}^2 + \text{uncertainty}^2}} )</td>
</tr>
<tr>
<td>Titrant (mM)</td>
<td>( m_{\text{titrant}} = \frac{m_{\text{sample}}}{\sqrt{\text{bias}^2 + \text{uncertainty}^2}} )</td>
</tr>
<tr>
<td>End point detection (ppm)</td>
<td>( m_{\text{end point}} = \frac{m_{\text{sample}}}{\sqrt{\text{bias}^2 + \text{uncertainty}^2}} )</td>
</tr>
</tbody>
</table>

**Results and Discussion**

**Comparing of Titration Systems and Detection Systems**

Figure 2 presents the relative standard uncertainties for the different titration systems evaluated, where it is observed that the uncertainties of the gravimetric methods present, in general, a decrease of 40% with respect to the volumetric titration. These differences are attributed to the better metrological characteristics of the mass instruments as compared to those of volumetric.

Figures 3 and 4 summarize the results of each uncertainty source compared. The results presented can be summarized in the following way:

a. The contribution due to the molecular mass of the PRM and its weighing are practically negligible.

b. The source associated with repeatability is not the most significant component.

c. For conditional detection, the most important uncertainty component is due to the error in detection of the end point.

d. For gravimetric titration with potentiometric detection, the most important uncertainty is associated to the purity of CRM.

e. When applying the classical method (see Table 1), the uncertainty is underestimated or overestimated if R is different to the instrument resolution.

The proposed approach applies for all cases because it does not depend on the instrument resolution. The new approach only depend on the amount of titrant added near the end point.

**Evaluation of the Bias**

Table 2 shows the results of bias for each system evaluated. According to the evaluation criterion (8), the non-significance of bias for all systems was obtained as a result.

**Conclusion**

In this study was found that less bias and uncertainties were obtained for the gravimetric method with potentiometric detection. A new approach was proposed for uncertainty evaluation associated to the end point detection. The results showed that with the classic approach (see Table 1) the uncertainty maybe until 6 times less that with the new approach.

**References**