

Oral solid dose

# Predicting softgel stability and shelf life using accelerated stability modeling

*Innovative technology provided early insight into degradation pathways and predicted shelf life for ibuprofen softgel formulations.*

## Development challenge

Understanding degradation pathways and shelf life is critical during formulation development, particularly for softgel products where interactions between the active ingredient and excipients can influence long-term stability.

For ibuprofen softgel formulations, predicting stability early in development could help guide formulation and packaging decisions without waiting for long-term stability studies to conclude.

## Applying predictive stability modeling

Predictive stability modeling approaches within the OSD Predict™ framework were used to evaluate degradation behavior under controlled stress conditions. Samples of 200 mg and 400 mg ibuprofen softgel formulations were exposed to a range of temperature and humidity conditions over a 21-day study period.

Samples were analyzed using a validated HPLC method to quantify impurity formation. The resulting data were used to model degradation kinetics using modified Arrhenius equations within ASAPprime® software.

The model outputs were then compared with historical ICH stability data to confirm predictive accuracy.

## Identifying degradation pathways

Analysis of the stressed samples identified multiple degradant species, including ibuprofen sorbitol esters and PEG-related degradants. Modeling results indicated that PEG-esters represented the shelf-life-limiting degradation products for both formulations.

Activation energy values for degradant growth were calculated at approximately  $32.1 \pm 17.6$  kcal/mol, supporting the degradation models used to estimate long-term stability.

## Development outcome

Predictive modeling estimated a shelf life of approximately 5.5 years for the 200 mg formulation and 3.8 years for the 400 mg formulation, reflecting higher degradation rates at the larger dose strength.

This modeling approach provided early insight into stability risk and enabled formulation teams to assess shelf-life expectations well before long-term stability studies were complete.

## At a glance

### Program focus

Evaluation of long-term stability and degradation pathways in ibuprofen softgel formulations.

### Methods used

Accelerated predictive stability modeling using ASAPprime® software and modified Arrhenius kinetics.

### Experimental conditions

Stress testing over 21 days across temperature ranges of 40–80°C and humidity levels of 11–75% RH, with impurity analysis via validated HPLC methods.

### Key technical finding

PEG-ester degradants were identified as the shelf-life-limiting species, with degradation behavior following zero-order kinetics.

### Development impact

Predictive modeling estimated shelf lives of ~5.5 years for the 200 mg softgel and ~3.8 years for the 400 mg formulation, enabling early assessment of formulation stability.

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