Soft Matter

ARTICLE

Electronic Supplementary Information

Bell-Evans Calculations

The Bell-Evans equation[1] is expanded to obtain a similar form to the straight line equation y=mx+c,

$$F(r) = \left(\frac{k_B T}{x_\beta}\right)\ln r + \left(\frac{k_B T}{x_\beta}\right)\ln\frac{x_\beta}{k_{off}\, k_B T}$$

Therefore when F(r) is plotted against ln r, the slope of the best fit line equals $\left(\frac{k_B T}{x_\beta}\right)$ and the y-intercept equals $\left(\frac{k_B T}{x_\beta}\right)\ln\frac{x_\beta}{k_{off}\, k_B T}$.

All values are converted to standard units, N and N/s. The width of the energy barrier, x_β is determined by the equation,

$$x_\beta = \frac{k_B T}{m}$$

Where m is the slope of the line. k_{off} was determined by rearranging the equation.

$$k_{off} = \frac{x_\beta}{k_B T\, e^{c x_\beta / k_B T}}$$

Where c is the y-intercept.

Once k_{off} is determined, we applied the following equation to determine the height of the energy barrier, ΔG[1].

$$k_{off}\,(F) = \left(\frac{k_B T}{h}\right) e^{-\frac{\Delta G - x_\beta F}{k_B\, T}}$$

Rearranged, ΔG can be determined as

$$-\Delta G = k_B T \ln\frac{k_0 h}{k_B T}$$

Where h is Plank's constant. For our purposes, we used $k_B T$ as units for ΔG.

Error Analysis

For the Bell-Evans model, errors were determined by the square root of the sum of the squares of the standard error[2]. For example, the standard error of x_β was calculated as follows:

Since x_β is a function of the slope, m,

$$x_\beta = \frac{k_B T}{m}$$

With m being the slope of the line using a least squares fit of the data points, the standard error of x_β is given by the equation,

$$\frac{\delta x_\beta}{x_\beta} = \sqrt{\left(\frac{\delta m}{m}\right)^2 + \left(\frac{\delta T}{T}\right)^2}$$

The standard error of the slope, m, was calculated using the graphing software. The standard error of the temperature was negligible, but still used and estimated as 1 K.

The standard error for all parameters using the Dudko-Hummer-Szabo model[3] were calculated using Origin v 9.0.

Hutter's thermal noise method[4] of cantilever spring constant calculation typically results in a standard error of 10-20%[5]. To calculate the standard errors for the Friddle-De Yoreo model[6], a 15% error was estimated for the cantilever spring constant. Since ΔG is a function of the cantilever spring constant and f_{eq}, the standard error in ΔG was estimated as

$$\delta\Delta G = \Delta G\sqrt{\left(\frac{\delta f_{eq}}{f_{eq}}\right)^2 + 0.15^2}$$

The remainder of standard errors were calculated in a manner similar to the Bell-Evans model.

Supplementary Information References

1 E. Evans, and K. Ritchie, *Biophys J.* 1997, **72**, 1541.

2 J. Taylor J. An Introduction to Error Analysis, 1997, Sausalito: University Science Books.

3 O. Dudko, G. Hummer, and A. Szabo A, *Proc. Nat. Acad. Sci.,* 2008, **105**, 15755.

4 J. Hutter, and J. Bechhoefer, *Rev. Sci. Instrum*., 1993, **64**, 1868.

5 JPK Instruments AG. Technical Summary: Calibration of atomic-force microscope tips.

6 R. Friddle, A. Noy, and J. De Yoreo, *Proc. Nat. Acad. Sci. USA*., 2012, **109**, 13573.