Table S1. Total energies (E_{Tot}, Hartree, calculated at the B3LYP/6-31G(d) level of theory for protonated Leu-enkephalin and at the B3LYP/6-31+G(d,p) level of theory for b_4 and a_4) of structures discussed in the manuscript. E_{Tot} of the $YGGF_{oxa}$ B, C, and E structures were given in Ref. 44.

Protonated Leu-enkephalin	
B	-1890.242063
C	-1890.242640
b_4 YGGF	
D	-1448.447700
B'	-1448.449953
C'	-1448.446003
E'	-1448.446316
a_4 YGGF	
B	-1335.105136
C	-1335.104492
D	-1335.100753
E	-1335.097088
F	-1335.109536

Reference 67 in full:
Case, D. A.; Pearlman, D. A.; Caldwell, J. W.; Cheatham III, T. E.; Ross, W. S.; Simmerling, C. L.; Darden, T. A.; Merz, K., M.; Stanton, R. V.; Cheng, A. L.; Vincent, J. J.; Crowley, M.; Tsui, V.; Radmer, R. J.; Duan, Y.; Pitera, J.; Massova, I. G.; Seibel, G. L.; Singh, U. C.; Weiner, P. K.; Kollmann, P. A. In; AMBER 99, University of California: San Francisco, 1999.

Reference 68 in full:
Frisch, M. J.; Trucks, G. W.; Schlegel, H. B.; Scuseria, G. E.; Robb, M. A.; Cheeseman, J. R.; Zakrzewski, V. G.; Montgomery, J. A. J.; Stratman, R. E.; Burant, J. C.; Dapprich, S.; Millam, J. M.; Daniels, A. D.; Kudin, A. N.; Strain, M. C.; Farkas, O.; Tomasi, J.; Barone, V.; Cossi, M.; Cammi, R.; Mennucci, B.; Pomelli, C.; Adamo, C.; Clifford, S.; Ochterski, J.; Petersson, G. A.; Ayala, P. Y.; Cui, Q.; Morokuma, K.; Malick, D. K.; Rabuck, A. D.; Raghavacchari, K.; Foresman, J. B.; Cioslowski, J.; Ortiz, J. V.; Stefanov, B. B.; Liu, G.; Liashenko, A.; Piskorz, P.; Komaromi, I.; Gombertz, R.; Martin, R. L.; Fox, D. J.; Keith, T.; Al-Laham, M. A.; Peng, C. Y.; Nanyakkara, A.; Gonzalez, C.; Challacombe, M.; Gill, P. M. W.; Johnsen, B. G.; Chen, W.; Wong, M. W.; Andres, J. L.; Head-Gordon, M.; Replogle, E. S.; Pople, J. A. In; Gaussian03, A.7 ed.; Gaussian Inc.: Pittsburgh, PA, 2003.

Figure S1. N-terminal amine and C-terminal oxazolone protonated $GGFY_{oxa}$, $GFYG_{oxa}$, and $FYGG_{oxa}$ structures. Relative energies (E_{Rel}) are calculated with respect to the N-terminal NH_2 protonated $YGGF_{oxa}$.

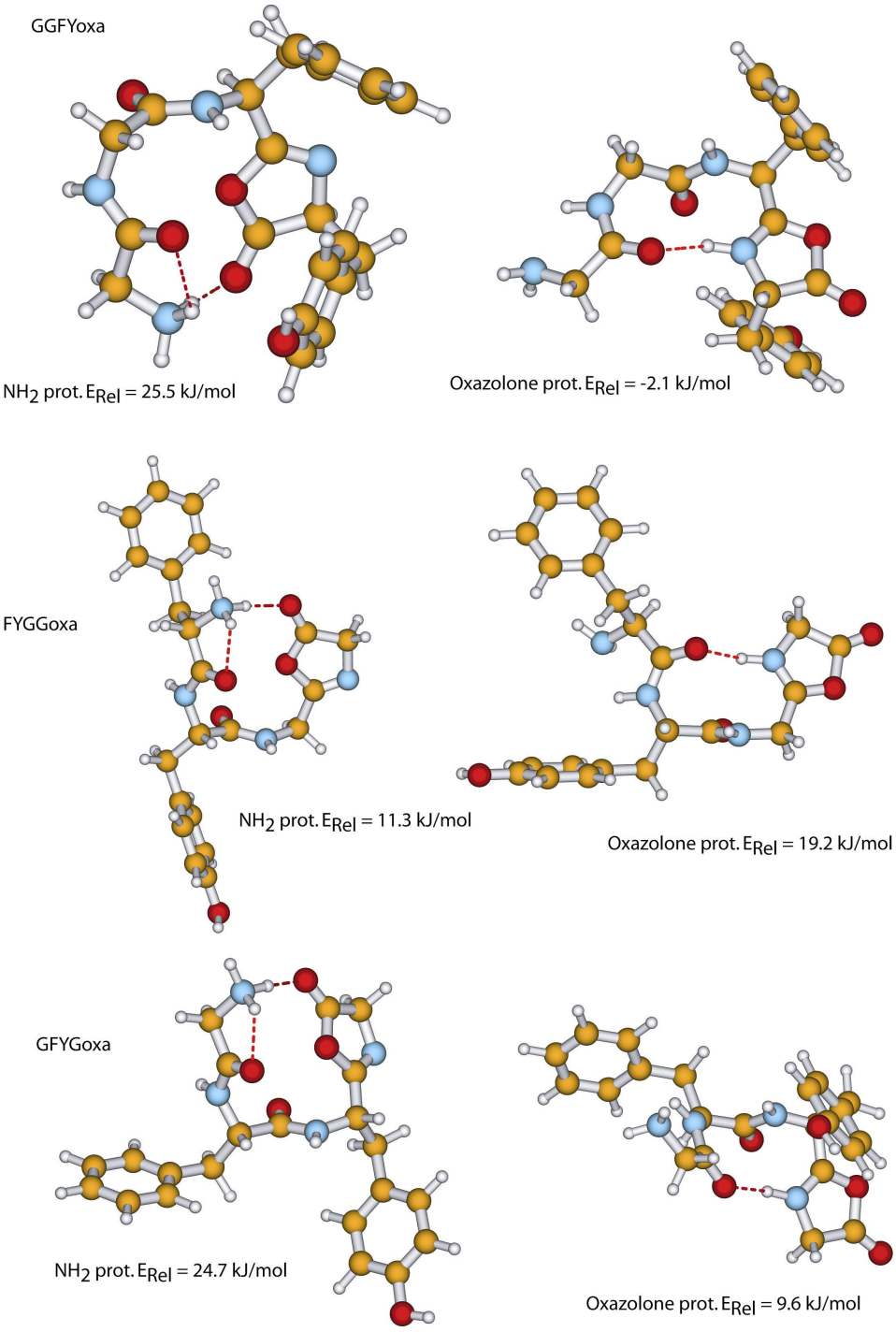

Figure S2. (A) Cyclic a_4, structures D_Phe and L_Phe. (B) IR photodepletion spectrum of the fragment ion a_4, compared to the calculated spectra (bold lines) for D_Phe (blue line) and L-Phe (red line).