**Supplementary material**

**Structural, energetic and spectroscopic characterization of 5-fluoracil anticarcinogenic drug isomers, tautomers and ions**

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**Table S1:** Main geometrical parameters (distances in Å and angles in degrees) of neutral 5-FU tautomers as evaluated using MP2/aug-cc-pVTZ for gas phase (GP) isolated species and PBE0/aug-cc-pVTZ when we considered one water (W) or with water molecule + model water solvent (PCM).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 5-FU1 | | | | 5-FU2 | | | 5-FU3 | | | 5-FU4 | | | 5-FU5 | | | 5-FU6 | | | 5-FU7 | | | 5-FU8 | | |
|  | GP | Exp.a)s | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM |
| N1-C2 | 1.380 | 1.385 | 1.398 | 1.387 | 1.404 | 1.420 | 1.406 | 1.293 | 1.307 | 1.311 | 1.408 | 1.349 | 1.346 | 1.348 | 1.336 | 1.337 | 1.333 | 1.367 | 1.363 | 1.382 | 1.373 | 1.366 | 1.382 | 1.365 | 1.360 |
| N1-C6 | 1.376 | 1.385 | 1.373 | 1.369 | 1.358 | 1.360 | 1.376 | 1.375 | 1.368 | 1.366 | 1.362 | 1.342 | 1.346 | 1.375 | 1.358 | 1.344 | 1.340 | 1.349 | 1.332 | 1.315 | 1.427 | 1.416 | 1.341 | 1.309 | 1.316 |
| N3-C2 | 1.385 | 1.408 | 1.390 | 1.387 | 1.385 | 1.381 | 1.360 | 1.353 | 1.353 | 1.355 | 1.375 | 1.326 | 1.342 | 1.364 | 1.333 | 1.331 | 1.382 | 1.427 | 1.416 | 1.441 | 1.343 | 1.332 | 1.321 | 1.404 | 1.374 |
| N3-C4 | 1.397 | 1.400 | 1.399 | 1.394 | 1.299 | 1.324 | 1.327 | 1.404 | 1.409 | 1.401 | 1.343 | 1.326 | 1.328 | 1.347 | 1.401 | 1.403 | 1.326 | 1.349 | 1.349 | 1.360 | 1.383 | 1.388 | 1.389 | 1.473 | 1.461 |
| C4-C5 | 1.457 | 1.478 | 1.456 | 1.447 | 1.423 | 1.433 | 1.426 | 1.448 | 1.444 | 1.438 | 1.419 | 1.407 | 1.406 | 1.406 | 1.384 | 1.380 | 1.393 | 1.400 | 1.391 | 1.377 | 1.396 | 1.391 | 1.463 | 1.351 | 1.391 |
| C5-C6 | 1.345 | 1.353 | 1.353 | 1.354 | 1.352 | 1.359 | 1.358 | 1.356 | 1.366 | 1.366 | 1.356 | 1.379 | 1.378 | 1.384 | 1.340 | 1.352 | 1.385 | 1.385 | 1.391 | 1.416 | 1.321 | 1.331 | 1.392 | 1.382 | 1.352 |
| C2-O2 | 1.216 | 1.233 | 1.220 | 1.355 | 1.217 | 1.224 | 1.236 | 1.342 | 1.346 | 1.340 | 1.214 | 1.332 | 1.337 | 1.391 | 1.334 | 1.337 | 1.279 | 1.240 | 1.249 | 1.220 | 1.238 | 1.249 | 1.259 | 1.329 | 1.326 |
| C4-O4 | 1.217 | 1.233 | 1.234 | 1.369 | 1.337 | 1.324 | 1.326 | 1.219 | 1.238 | 1.245 | 1.277 | 1.342 | 1.341 | 1.373 | 1.346 | 1.341 | 1.333 | 1.342 | 1.353 | 1.358 | 1.342 | 1.349 | 1.228 | 1.225 | 1.240 |
| N1-H1 | 1.007 |  | 1.014 | 1.228 | 1.009 | 1.015 | 1.017 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1.025 | 1.014 | 1.017 |
| N3-H3 | 1.012 |  | 1.036 | 1.242 |  |  |  | 1.012 | 1.040 | 1.038 |  |  |  |  |  |  |  |  |  |  |  |  | 1.357 | 1.342 | 1.329 |
| C5-F | 1.333 | 1.348 | 1.343 | 1.348 | 1.336 | 1.348 | 1.351 | 1.333 | 1.343 | 1.340 | 1.333 | 1.350 | 1.341 | 1.400 | 1.350 | 1.354 | 1.333 | 1.351 | 1.353 | 1.332 | 1.365 | 1.357 | 1.327 | 1.350 | 1.351 |
| H1-O2 |  |  |  |  |  |  |  | 0.969 | 0.976 | 1.038 | 0.950 | 0.976 | 0.976 | 0.972 | 0.999 | 0.976 |  |  |  |  |  |  |  |  |  |
| H3-O4 |  |  |  |  | 0.971 | 1.018 | 1.021 |  |  |  | 1.339 | 1.350 | 1.340 | 0.978 | 0.976 | 0.109 | 0.967 | 0.974 | 0.976 | 0.973 | 0.976 | 1.040 |  |  |  |
| N1C2N3 | 112.9 |  | 112.1 | 121.5 | 115.4 | 115.2 | 116.1 | 124.9 | 124.9 | 124.4 | 111.4 | 125.5 | 126.0 | 125.8 | 125.8 | 126.2 | 123.5 | 124.1 | 123.8 | 115.4 | 117.5 | 118.0 | 123.3 | 123.5 | 123.1 |
| C2N3C4 | 129.0 |  | 128.1 | 118.3 | 120.7 | 122.1 | 121.5 | 124.0 | 123.0 | 123.1 | 125.8 | 117.4 | 117.1 | 117.3 | 117.4 | 117.4 | 118.5 | 117.7 | 118.0 | 125.0 | 123.2 | 123.6 | 124.7 | 121.5 | 121.1 |
| N3C4C5 | 112.0 |  | 113.1 | 113.3 | 123.8 | 121.6 | 121.5 | 110.2 | 111.5 | 111.8 | 120.2 | 121.3 | 121.1 | 120.6 | 120.6 | 120.3 | 115.8 | 117.1 | 116.9 | 116.8 | 117.7 | 116.9 | 110.4 | 114.3 | 115.0 |
| C4C5C6 | 121.5 |  | 121.3 | 121.3 | 117.2 | 118.1 | 118.7 | 122.0 | 121.4 | 121.5 | 116.5 | 117.2 | 117.7 | 118.6 | 117.8 | 117.8 | 119.0 | 118.4 | 118.3 | 118.0 | 118.4 | 118.5 | 123.0 | 122.1 | 122.0 |
| C5C6N1 | 120.5 |  | 120.3 | 120.2 | 118.5 | 119.0 | 118.3 | 123.3 | 123.2 | 123.0 | 120.6 | 122.1 | 121.6 | 121.3 | 122.8 | 122.3 | 124.9 | 125.1 | 124.4 | 125.1 | 124.0 | 123.9 | 119.5 | 118.6 | 118.4 |
| C6N1C2 | 123.9 |  | 124.0 | 123.9 | 124.3 | 123.0 | 123.6 | 115.7 | 115.7 | 115.9 | 125.2 | 116.2 | 116.2 | 116.1 | 115.8 | 115.6 | 114.0 | 116.4 | 115.6 | 119.3 | 118.8 | 118.2 | 118.6 | 119.7 | 119.5 |
| H1O2C2 |  |  |  |  |  |  |  | 105.9 | 105.7 | 107.1 | 109.4 | 105.7 | 108.0 | 113.4 | 109.2 | 108.8 |  |  |  |  |  |  |  |  |  |
| H3O4C4 |  |  |  |  | 105.5 | 107.7 | 107.1 |  |  |  | 74.5 | 75.2 | 75.5 | 109.3 | 107.1 | 108.0 | 108.7 | 110.3 | 111.8 | 110.8 | 108.0 | 109.3 |  |  |  |

1. X-ray data (average for four molecules) from Ref. [15].

**Table S2:** Main geometrical parameters (distances in Å and angles in degrees) of neutral transition states (TS) as evaluated using MP2/aug-cc-pVTZ for gas phase (GP) isolated species and PBE0/aug-cc-pVTZ when we considered one water (W) or with water molecule + model water solvent (PCM).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TS12 | | | TS13 | | | TS24 | | | TS34 | | | TS45 | | | TS56 | | | TS67 | | | TS18 | | |
|  | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM |
| N1-C2 | 1.408 | 1.441 | 1.402 | 1.329 | 1.347 | 1.348 | 1.361 | 1.347 | 1.371 | 1.361 | 1.323 | 1.326 | 1.326 | 1.327 | 1.329 | 1.323 | 1.350 | 1.350 | 1.378 | 1.368 | 1.372 | 1.384 | 1.368 | 1.365 |
| N1-C6 | 1.362 | 1.376 | 1.362 | 1.368 | 1.364 | 1.362 | 1.340 | 1.353 | 1.345 | 1.340 | 1.341 | 1.356 | 1.343 | 1.342 | 1.350 | 1.341 | 1.396 | 1.399 | 1.314 | 1.340 | 1.325 | 1.313 | 1.338 | 1.375 |
| N3-C2 | 1.375 | 1.356 | 1.373 | 1.345 | 1.421 | 1.408 | 1.341 | 1.322 | 1.350 | 1.341 | 1.375 | 1.340 | 1.334 | 1.343 | 1.339 | 1.339 | 1.338 | 1.335 | 1.423 | 1.399 | 1.407 | 1.418 | 1.400 | 1.345 |
| N3-C4 | 1.343 | 1.358 | 1.357 | 1.415 | 1.451 | 1.368 | 1.322 | 1.414 | 1.326 | 1.322 | 1.423 | 1.372 | 1.321 | 1.379 | 1.342 | 1.323 | 1.334 | 1.342 | 1.351 | 1.367 | 1.352 | 1.344 | 1.338 | 1.387 |
| C4-C5 | 1.419 | 1.439 | 1.432 | 1.455 | 1.453 | 1.444 | 1.410 | 1.373 | 1.412 | 1.410 | 1.374 | 1.421 | 1.397 | 1.410 | 1.409 | 1.394 | 1.394 | 1.399 | 1.367 | 1.367 | 1.382 | 1.365 | 1.351 | 1.461 |
| C5-C6 | 1.356 | 1.364 | 1.359 | 1.356 | 1.360 | 1.362 | 1.372 | 1.345 | 1.373 | 1.372 | 1.356 | 1.373 | 1.374 | ­1.371 | 1.377 | 1.376 | 1.391 | 1.384 | 1.401 | 1.410 | 1.401 | 1.399 | 1.400 | 1.352 |
| C2-O2 | 1.214 | 1.223 | 1.235 | 1.280 | 1.287 | 1.288 | 1.281 | 1.286 | 1.297 | 1.281 | 1.283 | 1.287 | 1.345 | 1.349 | 1.337 | 1.341 | 1.334 | 1.343 | 1.217 | 1.224 | 1.248 | 1.216 | 1.291 | 1.288 |
| C4-O4 | 1.277 | 1.286 | 1.290 | 1.216 | 1.222 | 1.234 | 1.335 | 1.343 | 1.340 | 1.335 | 1.349 | 1.347 | 1.339 | 1.327 | 1327 | 1.340 | 1.344 | 1.337 | 1.333 | 1.342 | 1.349 | 1.338 | 1.224 | 1.239 |
| N1-H1 | 1.009 | 1.015 | 1.016 | 1.333 | 1.345 | 1.343 | 1.267 | 1.338 | 1.336 | 1.267 | 1.278 | 1.287 |  |  |  |  |  |  |  |  |  |  |  |  |
| N3-H3 |  |  |  | 1.012 | 1.019 | 1.019 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1.012 | 1.014 | 1.016 |
| C5-F | 1.334 | 1.343 | 1.351 | 1.334 | 1.345 | 1.353 | 1.337 | 1.350 | 1.352 | 1.337 | 1.348 | 1.356 | 1.336 | 1.347 | 1.351 | 1.333 | 1.351 | 1.355 | 1.340 | 1.350 | 1.349 | 1.351 | 1.342 | 1.351 |
| H1-O2 |  |  |  | 1.350 | 2.334 | 2.336 | 1.388 | 2.337 | 2.339 | 1.388 | 2.358 | 2.364 | 0.967 | 0.971 | 1.018 | 0.966 | 0.975 | 0.976 |  |  |  |  |  |  |
| H3-O4 | 1.339 | 2.355 | 2.334 |  |  |  | 0.971 | 0.979 | 0.979 | 0.971 | 0.976 | 0.977 | 0.969 | 0.976 | 0.973 | 0.969 | 0.978 | 0.978 | 0.965 | 1.028 | 0.976 | 0.968 | 0.976 | 1.016 |
| N1C2N3 | 111.4 | 114.3 | 115.1 | 122.0 | 119.3 | 119.4 | 123.9 | 121.5 | 122.3 | 123.9 | 126.3 | 126.3 | 127.4 | 126.8 | 126.9 | 127.3 | 121.2 | 122.0 | 115.7 | 116.7 | 117.5 | 115.9 | 120.2 | 120.0 |
| C2N3C4 | 125.8 | 124.5 | 124.0 | 122.8 | 126.1 | 125.7 | 115.2 | 118.5 | 118.2 | 115.2 | 119.9 | 119.8 | 116.4 | 117.9 | 117.8 | 116.8 | 118.6 | 118.6 | 125.3 | 124.2 | 124.1 | 124.6 | 123.8 | 123.5 |
| N3C4C5 | 120.2 | 118.3 | 118.2 | 112.2 | 110.9 | 111.4 | 123.6 | 122.3 | 121.9 | 123.6 | 122.8 | 122.5 | 121.2 | 119.0 | 119.1 | 120.6 | 121.2 | 120.9 | 116.7 | 116.3 | 117.0 | 117.4 | 113.5 | 114.1 |
| C4C5C6 | 116.5 | 119.1 | 119.4 | 123.1 | 121.8 | 121.9 | 118.7 | 117.2 | 117.8 | 118.7 | 115.8 | 116.0 | 117.6 | 118.2 | 118.5 | 117.6 | 117.6 | 116.8 | 117.8 | 118.4 | 118.3 | 118.2 | 119.1 | 119.0 |
| C5C6N1 | 120.6 | 119.6 | 119.7 | 119.2 | 122.4 | 122.1 | 117.3 | 120.5 | 120.1 | 117.3 | 119.5 | 119.4 | 121.7 | 122.3 | 122.5 | 122.3 | 121.2 | 123.5 | 125.4 | 125.1 | 124.1 | 124.5 | 122.1 | 122.0 |
| C6N1C2 | 125.2 | 124.3 | 123.8 | 120.5 | 119.2 | 119.1 | 121.1 | 119.6 | 119.5 | 121.1 | 122.8 | 121.9 | 115.5 | 115.5 | 115.4 | 115.1 | 116.9 | 116.8 | 118.7 | 119.0 | 118.7 | 119.1 | 120.9 | 121.1 |
| H1O2C2 |  |  |  | 74.0 | 107.3 | 107.3 | 73.5 | 74.8 | 74.5 | 73.5 | 74.8 | 64.9 | 105.8 | 110.2 | 109.7 | 106.5 | 105.8 | 105.3 |  |  |  |  |  |  |
| H3O4C4 |  |  |  |  |  |  | 105.9 | 105.1 | 107.2 | 105.9 | 105.9 | 107.2 | 106.0 | 107.2 |  | 106.3 | 107.5 | 107.3 | 110.8 | 111.5 | 111.3 | 110.9 | 112.3 | 111.8 |

**Table S3:** Relative energies (in eV) of neutral 5-FU tautomers and transition states. ‘opt’ stands for full optimization computations and ‘sp’ is for single point computations at the CCSD(T)-F12 level in junction with the aug-cc-pVXZ (x=D,T) and cc-pVDZ-F12 basis sets optimized geometry. These energies are given with respect to 5-FU1 minimal structure energy. We also give those computed at the PBE0/aug-cc-pVTZ (opt) with a water molecule and with water molecule +solvent (PCM model, water).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Method | 5-FU1 | TS12 | 5-FU2 | TS13 | 5-FU3 | TS24 | TS34 | 5-FU4 | TS45 | 5-FU5 | TS56 | 5-FU6 | TS67 | 5-FU7 | TS18 | 5-FU8 |
| B3LYP/6-311++G\*\*(opt) | 0 | 1.86 | 0.56 | 1.84 | 0.41 | 2.09 | 2.37 | 0.53 | 0.89 | 0.60 | 2.05 | 1.09 | 1.14 | 1.08 | 2.02 | 0.74 |
| PBE0/6-311++G\*\* (opt) | 0 | 1.80 | 0.55 | 1.78 | 0.40 | 2.02 | 2.30 | 0.50 | 1.05 | 0.56 | 1.98 | 1.10 | 1.19 | 0.83 | 1.95 | 0.73 |
| MP2/aug-cc-pVTZ (opt) | 0 | 1.89 | 0.50 | 1.84 | 0.33 | 2.05 | 2.32 | 0.35 | 0.85 | 0.4 | 2.08 | 1.09 | 1.16 | 0.88 | 2.00 | 0.65 |
| CCSD(T)-F12 / aug-cc-pVDZ (sp) | 0 | 1.98 | 0.52 | 2.06 | 0.35 | 2.08 | 2.41 | 0.41 | 0.90 | 0.46 | 1.99 | 1.11 | 1.18 | 0.89 | 2.18 | 0.66 |
| CCSD(T)-F12 / aug-cc-pVTZ (sp) | 0 | 1.98 | 0.52 | 1.96 | 0.35 | 2.10 | 2.47 | 0.41 | 0.90 | 0.46 | 2.09 | 1.10 | 1.15 | 0.87 | 2.08 | 0.42 |
| CCSD(T)-F12 / cc-pVDZ-F12 (sp) | 0 | 1.99 | 0.51 | 1.96 | 0.34 | 2.07 | 2.41 | 0.39 | 1.09 | 0.63 | 1.98 | 1.10 | 1.19 | 0.93 | 2.18 | 0.65 |
| SCF/DZP. a, | 0 | - | 0.60 | - | 0.36 | - | - | - | - | - | - | - | - | - | - | - |
| MP2/6-31G\*. b | 0 | - | 0.72 | - | 0.24 | - | - | 0.35 | - | - | - | - | - | - | - | - |
| PBE0 / aug-cc-pVTZ (opt)  with a water molecule | 0 | 0.46 | 0.35 | 0.36 | 0.33 | 0.67 | 0.62 | 0.43 | 0.76 | 0.43 | 0.97 | 0.84 | 0.98 | 0.71 | 0.55 | 0.49 |
| PBE0 / aug-cc-pVTZ (opt)  with water molecule + solvent  (PCM model, water) | 0 | 0.46 | 0.36 | 0.43 | 0.47 | 0.78 | 0.79 | 0.47 | 0.91 | 0.66 | 0.98 | 0.81 | 0.98 | 0.74 | 0.50 | 0.42 |

1. Ref. [18].
2. Ref. [47].

**Table S4:** Scaled anharmonic frequencies of 5-FU isomers as computed at the MP2/aug-cc-pVTZ level.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| NO. | Sym | 5-FU1 | | | | 5-FU2 | 5-FU3 | 5-FU4 | 5-FU5 | 5-FU6 | 5-FU7 | 5-FU8 |
| This work | Exp a, b | Theo c, d, e, f | Characterization g |
| 1 | a′ | 3485 | 3480.0 a,b | 3468 c, d  3480.1e  3468f | 100 ν (N1 -H7) | 3553 | 3593 | 3602 | 3615 | 3629 | 3597 | 3586 |
| 2 | a′ | 3427 | 3427.5 a, b | 3416 c, d  3427.4e  3416f | 100 ν (N 3 -H9) | 3453 | 3418 | 3573 | 3583 | 3415 | 3421 | 3482 |
| 3 | a′ | 3102 | - | - | 99ν(C 6 -H12) | 3103 | 3077 | 3068 | 3064 | 3029 | 3027 | 3113 |
| 4 | a′ | 1719 | 1780.0 a,b  1778.0b,  1768.0b,  1761.0b,  1755.0b | 1781-1706 c  1742 d  1767.8 e | 73ν(C 2 d O8) | 1694 | 1699 | 1601 | 1611 | 1700 | 1697 | 1657 |
| 5 | a′ | 1690 | 1746.5a, b  1742.5b  1708.5b  1705.5b | 1781-1706 c  1754d,  1742.3e  1754f | 78ν(C 4 d O10) | 1639 | 1596 | 1581 | 1570 | 1650 | 1639 | 1627 |
| 6 | a′ | 1635 | 1686.5b  1684.5b | 1621c  1685 d  1685f | 71ν(C 5 dC 6) | 1545 | 1565 | 1451 | 1460 | 1541 | 1552 | 1572 |
| 7 | a′ | 1441 | 1686.5a  1472.0b | 1477 c,d  1477f | 31 β(N 1 -H 7 ) – 19ν 3 (M) + 13ν 2 (R) | 1468 | 1478 | 1427 | 1399 | 1426 | 1451 | 1522 |
| 8 | a′ | 1366 | 1472.0a  1400.5b | 1412d  1412f | 29ν 3 (M) + 21β(N 1 -H 7 ) – 11β as (CdO) | 1388 | 1355 | 1347 | 1353 | 1367 | 1365 | 1341 |
| 9 | a′ | 1328 | 1400.5a  1367.0b | 1399c  1386 d  1386f | 64β(N 3 -H 9 ) | 1280 | 1277 | 1302 | 1304 | 1286 | 1283 | 1309 |
| 10 | a′ | 1298 | 1367.0a  1333.5b | 1182c  1334 d  1334f | 46β(C 6 -H 12 ) + 16ν 2 (R) + 11ν 1 (R | 1234 | 1232 | 1240 | 1249 | 1255 | 1254 | 1237 |
| 11 | a′ | 1230 | 1333a  1247.5b | 1253c  1247 d  1247f | 44ν(C 5 -F 11 ) + 14ν 3 (M) + 14β 1 (R) | 1189 | 1227 | 1225 | 1223 | 1212 | 1198 | 1189 |
| 12 | a′ | 1154 | 1247a  1184.0b  1180.7b | 1182f | 41ν 2 (R) - 21β(C 6 -H 12 ) + 11ν as (CN) | 1161 | 1146 | 1185 | 1169 | 1113 | 1138 | 1156 |
| 13 | a′ | 1109 | 1184a  1147.0b  1145.5b | - | 45ν as (CN) + 18β(N 1 -H 7 ) | 1085 | 1112 | 1105 | 1112 | 1051 | 1060 | 1068 |
| 14 | a′ | 930 | 1147a  959.5b | 1050d  961f | 48ν 1 (R) | 908 | 973 | 965 | 961 | 937 | 932 | 964 |
| 15 | a′ | 848 | 959a  806.5b | 876 c  807 d  876 f | 57β 1 (R) - 16ν(C 5 -F 11 ) | 859 | 893 | 908 | 913 | 892 | 885 | 820 |
| 16 | a′ | 775 | 876a | 807 f | 68ν(B) | 762 | 751 | 761 | 762 | 759 | 754 | 767 |
| 17 | a′ | 732 | 806a | 731 d  757 f | 69β s (CdO) | 735 | 734 | 757 | 755 | 740 | 742 | 750 |
| 18 | a′ | 514 | 527.0a  532.0b | 539 c, d  539 f | 93γ(C 6 -H 12 ) | 567 | 517 | 520 | 502 | 521 | 521 | 507 |
| 19 | a′ | 505 | 532.0a  451.0b | - | 66γ(C 4 dO 10 ) + 10γ 1 (R) - 10γ(C 2 dO 8 ) | 513 | 474 | 503 | 471 | 443 | 442 | 468 |
| 20 | a′ | 646 | 653a | 571c  653f | 60β as (CdO) + 12ν 3 (M) - 11ν as (CN) | 606 | 652 | 572 | 571 | 588 | 613 | 585 |
| 21 | a′ | 598 | - | 640 d | 81β(C 5 -F 11 ) | 582 | 583 | 528 | 535 | 553 | 588 | 511 |
| 22 | a″ | 716 | 756a  876.5b | 961d  750 f | 61β 3 (R) | 718 | 722 | 741 | 741 | 739 | 737 | 722 |
| 23 | a″ | 709 | 749a  757.5b | 806 c  757 f | 76β 2 (R) | 716 | 701 | 696 | 693 | 661 | 663 | 703 |
| 24 | a″ | 430 | 451.0a  749.5b | 757 c  750 d  470f | 83γ(C 2 dO 8 ) - 13γ(C 4 dO 10 ) | 457 | 440 | 466 | 462 | 427 | 432 | 446 |
| 25 | a″ | 368 | 653.0b | 653 c, d  405 f | 86γ(N 3 -H 9 ) | 385 | 397 | 435 | 435 | 350 | 417 | 387 |
| 26 | a″ | 364 | 527.0b | 393c  370 f | 94γ(N 1 -H 7 ) | 369 | 376 | 367 | 365 | 314 | 351 | 350 |
| 27 | a″ | 327 | - | - | 68γ 1 (R) + 15γ(C 4 dO 10 ) | 322 | 342 | 347 | 347 | 268 | 301 | 346 |
| 28 | a″ | 286 | - | - | 87γ(C 5 -F 11 ) | 274 | 286 | 271 | 270 | 191 | 253 | 291 |
| 29 | a″ | 142 | - | - | 90γ 2 (R) | 205 | 166 | 223 | 226 | 183 | 193 | 185 |
| 30 | a″ | 108 | - | - | 81γ 3 (R) | 93 | 130 | 126 | 125 | 96 | 96 | 96 |

1. Ref. [12].
2. Ref. [47].
3. Ref. [59].
4. Ref. [52].
5. Ref. [16].
6. Ref. [60].
7. Ref. [10].

**Table S5:** Frequencies (in cm-1) of neutral transition states as computed using the MP2/aug-cc-pVTZ level of theory.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| NO. | TS12 | TS13 | TS18 | TS34 | TS24 | TS45 | TS56 | TS67 |
| 1 | 3597 | 3630 | 3660 | 3738 | 3755 | 3768 | 3779 | 3688 |
| 2 | 3251 | 3249 | 3268 | 3247 | 3213 | 3555 | 3203 | 3495 |
| 3 | 2146 | 2121 | 2145 | 2155 | 2155 | 3204 | 2174 | 3060 |
| 4 | 1774 | 1801 | 1764 | 1700 | 1708 | 1666 | 1727 | 1733 |
| 5 | 1690 | 1701 | 1695 | 1634 | 1677 | 1636 | 1632 | 1648 |
| 6 | 1640 | 1645 | 1672 | 1600 | 1618 | 1509 | 1595 | 1535 |
| 7 | 1579 | 1530 | 1551 | 1505 | 1587 | 1453 | 1521 | 1414 |
| 8 | 1396 | 1427 | 1442 | 1419 | 1479 | 1372 | 1374 | 1380 |
| 9 | 1361 | 1367 | 1370 | 1326 | 1412 | 1359 | 1320 | 1263 |
| 10 | 1324 | 1333 | 1306 | 1295 | 1398 | 1295 | 1293 | 1250 |
| 11 | 1265 | 1257 | 1280 | 1258 | 1304 | 1283 | 1225 | 1208 |
| 12 | 1162 | 1177 | 1147 | 1197 | 1205 | 1173 | 1210 | 1123 |
| 13 | 1031 | 1101 | 1075 | 1078 | 1123 | 1015 | 1054 | 1026 |
| 14 | 1006 | 1027 | 1053 | 1002 | 1032 | 962 | 1034 | 922 |
| 15 | 915 | 918 | 857 | 934 | 938 | 919 | 974 | 893 |
| 16 | 862 | 822 | 836 | 861 | 872 | 807 | 825 | 778 |
| 17 | 766 | 759 | 770 | 780 | 780 | 780 | 786 | 749 |
| 18 | 749 | 749 | 758 | 774 | 774 | 761 | 758 | 737 |
| 19 | 703 | 724 | 702 | 724 | 773 | 636 | 696 | 634 |
| 20 | 672 | 650 | 653 | 658 | 673 | 576 | 653 | 606 |
| 21 | 667 | 600 | 560 | 574 | 563 | 555 | 585 | 581 |
| 22 | 546 | 599 | 520 | 563 | 571 | 517 | 505 | 528 |
| 23 | 463 | 470 | 480 | 493 | 665 | 492 | 466 | 451 |
| 24 | 416 | 398 | 408 | 425 | 478 | 442 | 432 | 430 |
| 25 | 394 | 398 | 407 | 417 | 418 | 373 | 385 | 355 |
| 26 | 350 | 346 | 355 | 341 | 333 | 340 | 327 | 304 |
| 27 | 304 | 296 | 304 | 291 | 293 | 284 | 279 | 276 |
| 28 | 157 | 174 | 162 | 215 | 209 | 192 | 206 | 183 |
| 29 | 126 | 119 | 119 | 119 | 116 | 139 | 116 | 82 |
| 30 | i1858 | i1854 | i1853 | i1835 | i1889 | i472 | i1835 | i380 |

**Table S6:** Main geometrical parameters (distances in Å and angles in degrees) of cationic 5-FU tautomers as evaluated using MP2/aug-cc-pVTZ for isolated species and PBE0/aug-cc-pVTZ when we considered a water molecule (W) or with water molecule + model water solvent (PCM).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 5-FU1+ | | | 5-FU2+ | | | 5-FU3+ | | | 5-FU4+ | | | 5-FU5+ | | | 5-FU6+ | | | 5-FU7+ | | | 5-FU8+ | | | |
|  | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | | GP | W | PCM |
| N1-C2 | 1.448 | 1.455 | 1.439 | 1.451 | 1.459 | 1.406 | 1.353 | 1.360 | 1.361 | 1.376 | 1.390 | 1.389 | 1.372 | 1.384 | 1.385 | 1.374 | 1.386 | 1.390 | 1.385 | 1.390 | 1.392 | | 1.411 | 1.411 | 1.420 |
| N1-C6 | 1.319 | 1.328 | 1.323 | 1.317 | 1.324 | 1.376 | 1.316 | 1.324 | 1.321 | 1.307 | 1.314 | 1.312 | 1.307 | 1.313 | 1.313 | 1.302 | 1.315 | 1.315 | 1.321 | 1.315 | 1.314 | | 1.325 | 1.339 | 1.324 |
| N3-C2 | 1.370 | 1.368 | 1.369 | 1.366 | 1.360 | 1.327 | 1.331 | 1.333 | 1.335 | 1.334 | 1.351 | 1.352 | 1.339 | 1.355 | 1.355 | 1.454 | 1.451 | 1.424 | 1.449 | 1.437 | 1.421 | | 1.276 | 1.305 | 1.303 |
| N3-C4 | 1.392 | 1.395 | 1.387 | 1.298 | 1.323 | 1.327 | 1.416 | 1.413 | 1.402 | 1.309 | 1.313 | 1.313 | 1.312 | 1.315 | 1.314 | 1.318 | 1.339 | 1.344 | 1.351 | 1.321 | 1.324 | | 1.388 | 1.377 | 1.376 |
| C4-C5 | 1.483 | 1.489 | 1.481 | 1.448 | 1.457 | 1.426 | 1.463 | 1.472 | 1.469 | 1.450 | 1.448 | 1.445 | 1.449 | 1.447 | 1.445 | 1.434 | 1.444 | 1.447 | 1.381 | 1.434 | 1.437 | | 1.475 | 1.485 | 1.483 |
| C5-C6 | 1.400 | 1.402 | 1.402 | 1.399 | 1.402 | 1.360 | 1.408 | 1.410 | 1.408 | 1.415 | 1.417 | 1.415 | 1.415 | 1.417 | 1.415 | 1.409 | 1.412 | 1.408 | 1.404 | 1.409 | 1.409 | | 1.400 | 1.392 | 1.403 |
| C2-O2 | 1.194 | 1.210 | 1.215 | 1.205 | 1.221 | 1.236 | 1.292 | 1.312 | 1.309 | 1.291 | 1.286 | 1.288 | 1.291 | 1.289 | 1.285 | 1.195 | 1.213 | 1.222 | 1.220 | 1.219 | 1.224 | | 1.309 | 1.293 | 1.292 |
| C4-O4 | 1.201 | 1.214 | 1.221 | 1.304 | 1.291 | 1.326 | 1.204 | 1.217 | 1.222 | 1.296 | 1.315 | 1.315 | 1.296 | 1.316 | 1.316 | 1.290 | 1.389 | 1.275 | 1.343 | 1.314 | 1.307 | | 1.215 | 1.232 | 1.233 |
| N1-H1 | 1.019 | 1.024 | 1.024 | 1.009 | 1.024 | 1.017 | 2.301 | 2.286 | 2.269 |  |  |  |  |  |  |  |  |  |  |  |  | | 1.019 | 1.023 | 1.024 |
| N3-H3 | 1.017 | 1.070 | 1.066 |  |  |  | 1.019 | 1.072 | 1.079 |  |  |  |  |  |  |  |  |  |  |  |  | |  |  |  |
| C5-F | 1.284 | 1.297 | 1.300 | 1.291 | 1.306 | 1.351 | 1.289 | 1.302 | 1.306 | 1.289 | 1.307 | 1.309 | 1.290 | 1.307 | 1.309 | 1.291 | 1.310 | 1.311 | 1.369 | 1.321 | 1.315 | | 1.287 | 1.305 | 1.303 |
| H1-O2 |  |  |  |  |  |  | 0.974 | 0.982 | 0.982 | 0.975 | 1.064 | 1.079 | 0.974 | 1.056 | 1.076 |  |  |  |  |  |  | |  |  |  |
| H3-O4 |  |  |  | 0.973 | 1.057 | 1.021 |  |  |  | 0.975 | 0.983 | 0.983 | 0.974 | 0.983 | 0.983 | 0.969 | 1.084 | 1.103 | 0.976 | 1.084 | 1.084 | |  |  |  |
| N1C2N3 | 113.4 | 114.4 | 114.9 | 117.1 | 117.9 | 116.1 | 124.2 | 125.0 | 125.4 | 122.0 | 126.7 | 126.8 | 128.1 | 126.9 | 126.9 | 117.7 | 117.9 | 118.7 | 115.8 | 119.3 | 119.7 | | 123.9 | 122.6 | 122.9 |
| C2N3C4 | 127.8 | 127.0 | 126.7 | 120.9 | 121.6 | 121.5 | 122.9 | 121.7 | 121.6 | 116.1 | 117.1 | 116.8 | 116.3 | 116.9 | 117.1 | 123.8 | 124.3 | 124.4 | 124.2 | 122.3 | 122.6 | | 120.1 | 120.9 | 120.5 |
| N3C4C5 | 112.8 | 113.2 | 113.2 | 121.7 | 119.9 | 121.5 | 111.8 | 112.6 | 112.7 | 120.7 | 120.4 | 120.4 | 120.3 | 120.4 | 120.1 | 115.8 | 114.9 | 114.4 | 117.2 | 116.9 | 116.7 | | 116.4 | 116.5 | 116.4 |
| C4C5C6 | 122.1 | 122.4 | 122.3 | 118.9 | 119.9 | 118.7 | 121.1 | 121.2 | 121.4 | 117.9 | 118.1 | 118.4 | 118.0 | 118.1 | 118.4 | 119.6 | 120.1 | 120.4 | 118.5 | 120.0 | 119.8 | | 120.9 | 120.7 | 121.4 |
| C5C6N1 | 118.0 | 117.7 | 117.8 | 117.3 | 117.5 | 118.3 | 121.7 | 121.3 | 121.1 | 120.3 | 121.0 | 121.1 | 120.8 | 121.1 | 121.1 | 122.9 | 123.0 | 122.6 | 124.5 | 122.0 | 122.1 | | 117.1 | 117.6 | 116.7 |
| C6N1C2 | 125.7 | 125.1 | 124.9 | 123.5 | 122.9 | 123.6 | 118.0 | 117.8 | 117.5 | 116.6 | 116.4 | 116.5 | 116.2 | 116.4 | 116.2 | 119.9 | 119.5 | 119.1 | 119.4 | 119.2 | 118.9 | | 121.3 | 121.3 | 121.9 |
| H1O2C2 |  |  |  |  |  |  | 110.2 | 108.8 | 109.3 | 110.2 | 111.8 | 111.9 | 110.0 | 114.8 | 112.2 |  |  |  |  |  |  | |  |  |  |
| H3O4C4 |  |  |  | 110.0 | 112.0 | 107.1 |  |  |  | 110.4 | 109.4 | 109.4 | 110.8 | 109.4 | 109.4 | 115.8 | 114.2 | 115.0 | 108.3 | 111.9 | 112.3 | | 105.8 | 111.9 | 111.4 |

**Table S7:** Main geometrical parameters (distances in Å and angles in degrees) of cationic transition states (TS) as evaluated using MP2/aug-cc-pVTZ for isolated species and PBE0/aug-cc-pVTZ when we considered water (+H2O) or with water molecule + model water solvent (PCM).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TS12+ | | | TS13+ | | | TS24+ | | | TS34+ | | | TS45+ | | | TS56+ | | | TS67+ | | | TS18+ | | |
|  | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM | GP | W | PCM |
| N1-C2 | 1.474 | 1.463 | 1.451 | 1.389 | 1.411 | 1.348 | 1.419 | 1.427 | 1.415 | 1.322 | 1.427 | 1.379 | 1.343 | 1.357 | 1.379 | 1.348 | 1.386 | 1.391 | 1.386 | 1.357 | 1.390 | 1.340 | 1.331 | 1.365 |
| N1-C6 | 1.312 | 1.325 | 1.320 | 1.309 | 1.322 | 1.362 | 1.312 | 1.315 | 1.312 | 1.351 | 1.315 | 1.317 | 1.346 | 1.320 | 1.314 | 1.309 | 1.314 | 1.314 | 1.313 | 1.320 | 1.312 | 1.388 | 1.333 | 1.375 |
| N3-C2 | 1.355 | 1.356 | 1.354 | 1.329 | 1.367 | 1.368 | 1.338 | 1.364 | 1.366 | 1.343 | 1.364 | 1.368 | 1.350 | 1.326 | 1.332 | 1.391 | 1.418 | 1.399 | 1.465 | 1.326 | 1.427 | 1.333 | 1.332 | 1.345 |
| N3-C4 | 1.334 | 1.361 | 1.354 | 1.417 | 1.409 | 1.408 | 1.304 | 1.309 | 1.310 | 1.363 | 1.306 | 1.322 | 1.346 | 1.342 | 1.331 | 1.306 | 1.317 | 1.313 | 1.333 | 1.342 | 1.321 | 1.391 | 1.378 | 1.387 |
| C4-C5 | 1.451 | 1.474 | 1.468 | 1.485 | 1.477 | 1.444 | 1.459 | 1.445 | 1.442 | 1.406 | 1.445 | 1.461 | 1.430 | 1.450 | 1.454 | 1.449 | 1.443 | 1.440 | 1.435 | 1.450 | 1.433 | 1.478 | 1.488 | 1.461 |
| C5-C6 | 1.407 | 1.402 | 1.402 | 1.406 | 1.407 | 1.362 | 1.401 | 1.412 | 1.411 | 1.375 | 1.412 | 1.410 | 1.391 | 1.400 | 1.415 | 1.418 | 1.412 | 1.410 | 1.423 | 1.400 | 1.416 | 1.348 | 1.398 | 1.352 |
| C2-O2 | 1.189 | 1.219 | 1.224 | 1.240 | 1.243 | 1.286 | 1.247 | 1.215 | 1.258 | 1.333 | 1.251 | 1.239 | 1.330 | 1.327 | 1.316 | 1.245 | 1.244 | 1.251 | 1.212 | 1.290 | 1.225 | 1.281 | 1.258 | 1.288 |
| C4-O4 | 1.243 | 1.251 | 1.259 | 1.191 | 1.212 | 1.234 | 1.289 | 1.318 | 1.321 | 1.275 | 1.318 | 1.288 | 1.337 | 1.290 | 1.289 | 1.289 | 1.318 | 1.315 | 1.319 | 1.327 | 1.323 | 1.215 | 1.226 | 1.239 |
| N1-H1 | 1.020 | 1.024 | 1.023 | 1.307 | 1.023 | 1.023 | 1.331 | 1.308 | 1.312 | 1.304 | 1.308 | 1.308 |  |  |  |  |  |  |  |  |  | 1.006 | 1.023 | 1.016 |
| N3-H3 | 1.340 | 1.558 | 1.599 | 1.018 | 1.029 | 1.019 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 1.336 | 1.558 | 1.598 |
| C5-F | 1.281 | 1.302 | 1.303 | 1.283 | 1.303 | 1.303 | 1.289 | 1.312 | 1.312 | 1.343 | 1.348 | 1.351 | 1.288 | 1.310 | 1.307 | 1.288 | 1.309 | 1.313 | 1.308 | 1.310 | 1.308 | 1.333 | 1.301 | 1.351 |
| H1-O2 |  |  |  | 1.349 | 2.428 | 2.424 | 1.384 | 2.421 | 2.479 | 0.967 | 0.983 | 1.016 | 0.982 | 1.065 | 1.067 | 1.363 | 0.979 | 0.979 |  |  |  |  |  |  |
| H3-O4 | 1.353 | 2.472 | 2.473 |  |  |  | 0.963 | 0.983 | 0.982 | 1.372 | 2.421 | 2.410 | 0.988 | 0.975 | 0.982 | 0.970 | 0.978 | 0.978 | 0.978 | 1.065 | 0.981 |  |  |  |
| N1C2N3 | 112.3 | 116.6 | 117.2 | 121.9 | 118.7 | 119.4 | 125.9 | 122.5 | 123.3 | 123.2 | 122.5 | 123.5 | 114.1 | 122.4 | 126.8 | 126.1 | 122.5 | 122.8 | 117.6 | 117.8 | 119.1 | 123.3 | 119.9 | 120.0 |
| C2N3C4 | 126.0 | 123.8 | 123.2 | 121.4 | 126.0 | 125.7 | 113.8 | 119.0 | 118.3 | 121.6 | 119.0 | 120.0 | 125.3 | 122.3 | 122.8 | 121.4 | 119.6 | 120.0 | 123.2 | 122.4 | 122.9 | 124.4 | 122.7 | 123.5 |
| N3C4C5 | 119.5 | 116.9 | 117.1 | 113.3 | 111.5 | 111.4 | 123.1 | 120.7 | 120.8 | 117.4 | 120.7 | 119.0 | 118.4 | 119.0 | 119.1 | 114.7 | 116.0 | 116.3 | 115.3 | 117.8 | 116.5 | 110.8 | 115.5 | 114.1 |
| C4C5C6 | 117.5 | 121.1 | 121.0 | 122.9 | 121.8 | 121.9 | 120.6 | 118.5 | 118.7 | 117.0 | 118.5 | 118.3 | 117.2 | 117.8 | 117.8 | 120.2 | 118.0 | 117.5 | 119.1 | 119.1 | 119.8 | 123.7 | 121.5 | 122.0 |
| C5C6N1 | 118.8 | 117.5 | 117.4 | 116.7 | 121.2 | 122.6 | 114.8 | 120.3 | 120.1 | 123.9 | 120.3 | 122.0 | 118.0 | 119.1 | 119.1 | 123.0 | 121.9 | 121.9 | 122.9 | 120.7 | 122.1 | 119.6 | 122.6 | 121.1 |
| C6N1C2 | 125.7 | 121.3 | 121.8 | 123.5 | 120.4 | 119.1 | 121.4 | 118.6 | 118.5 | 116.6 | 118.6 | 118.6 | 126.8 | 124.8 | 124.8 | 114.3 | 116.9 | 116.0 | 119.7 | 118.9 | 118.9 | 118.0 | 117.7 | 119.0 |
| H1O2C2 |  |  |  | 77.3 | 0.2 | 103.3 | 78.7 | 71.5 | 65.3 | 107.0 | 108.3 | 108.3 | 120.6 | 120.7 | 120.7 | 106.5 | 109.8 | 110.0 |  |  |  |  |  |  |
| H3O4C4 |  |  |  |  |  |  | 109.3 | 108.8 | 108.8 | 75.2 | 71.5 | 70.9 | 114.6 | 115.7 | 115.6 | 113.5 | 112.0 | 110.9 | 117.8 | 114.0 | 114.7 |  |  |  |

**Table S8:** Relative energies (in eV) of 5-FU+ cation tautomers and transition states. ‘opt’ stands for full optimization computations and ‘sp’ is for single point computations at the RCCSD(T)-F12 level. These energies are given with respect to 5-FU1+ minimal structure energy. We also give those computed at the PBE0 / aug-cc-pVTZ (opt) with a water molecule and with water molecule +solvent (PCM model, water).

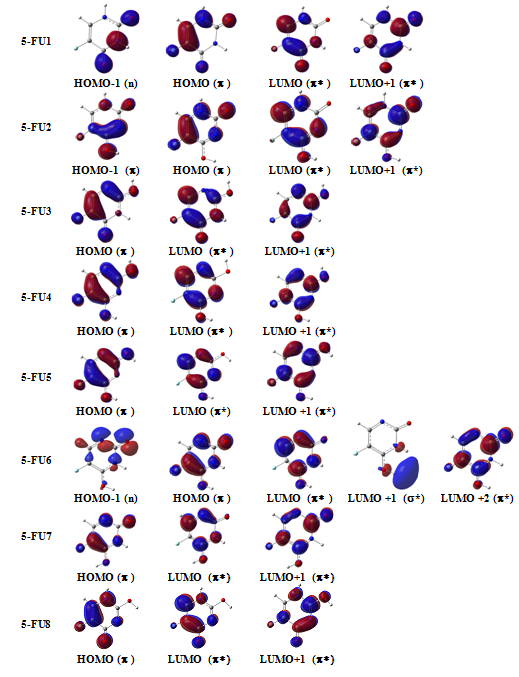
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 5-FU1+ | TS12+ | 5-FU2+ | TS13+ | 5-FU3+ | TS24+ | TS34+ | 5-FU4+ | TS45+ | 5-FU5+ | TS56+ | 5-FU6+ | TS67+ | 5-FU7+ | TS18+ | 5-FU8+ |
| B3LYP / 6-311++G\*\* (opt) | 0 | 1.98 | 0.40 | 1.50 | 0.15 | 2.02 | 2.05 | 0.69 | 0.85 | 0.54 | 2.05 | 0.67 | 0.91 | 0.74 | 2.02 | 0.76 |
| PBE0 / 6-311++G\*\* (opt) | 0 | 2.02 | 0.28 | 1.56 | 0.02 | 2.09 | 1.87 | 0.57 | 0.76 | 0.39 | 1.77 | 0.39 | 0.78 | 0.60 | 1.86 | 0.56 |
| RMP2 / aug-cc-pVTZ (opt) | 0 | 2.19 | 0.35 | 1.66 | 0.09 | 1.93 | 2.44 | 0.40 | 0.79 | 0.43 | 1.84 | 0.41 | 0.68 | 0.14 | 1.94 | 0.37 |
| RCCSD(T)-F12 /  aug-cc-pVDZ (sp) | 0 | 2.17 | 0.33 | 1.99 | 0.14 | 2.04 | 2.34 | 0.36 | 0.82 | 0.40 | 1.95 | 0.41 | 0.74 | 0.26 | 1.97 | 0.47 |
| RCCSD(T)-F12 /  aug-cc-pVTZ (sp) | 0 | 2.31 | 0.24 | 2.06 | 0.08 | 2.11 | 2.41 | 0.40 | 0.82 | 0.43 | 1.99 | 0.51 | 0.71 | 0.20 | 1.99 | 0.40 |
| RCCSD(T)-F12 /  cc-pVDZ-F12 (sp) | 0 | 2.15 | 0.12 | 1.91 | -0.05 | 1.95 | 2.31 | 0.31 | 0.71 | 0.36 | 1.91 | 0.41 | 0.74 | 0.15 | 1.89 | 0.33 |
| PBE0 / aug-cc-pVTZ (opt)  with a water molecule | 0 | 0.39 | 0.16 | 0.12 | 0.06 | 0.48 | 0.41 | 0.23 | 0.79 | 0.29 | 0.68 | 0.24 | 0.76 | 0.40 | 0.54 | 0.39 |
| PBE0 / aug-cc-pVTZ (opt)  with water molecule +solvent (PCM model,water) | 0 | 0.41 | 0.26 | 0.17 | 0.06 | 0.67 | 0.66 | 0.56 | 1.07 | 0.56 | 0.74 | 0.22 | 0.84 | 0.50 | 0.51 | 0.42 |

**Table S9:** Scaled anharmonic frequencies (in cm-1) of cationic 5-FU and their tautomeres, using RMP2/aug-cc-pVTZ level of Theory. Scaling factor=0.953 [29].

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| NO. | Sym | 5-FU1+ | 5-FU2+ | 5-FU3+ | 5-FU4+ | 5-FU5+ | 5-FU6+ | 5-FU7+ | 5-FU8+ |
| 1 | a′ | 3384 | 3442 | 3492 | 3453 | 3538 | 3499 | 3435 | 3438 |
| 2 | a′ | 3351 | 3384 | 3339 | 3484 | 3475 | 3374 | 3255 | 3375 |
| 3 | a′ | 3098 | 3102 | 3061 | 3070 | 3105 | 3034 | 2943 | 3105 |
| 4 | a′ | 1689 | 1569 | 1581 | 1553 | 1543 | 1601 | 1520 | 1595 |
| 5 | a′ | 1672 | 1677 | 1680 | 1574 | 1573 | 1661 | 1577 | 1677 |
| 6 | a′ | 1556 | 1512 | 1535 | 1502 | 1488 | 1524 | 1441 | 1514 |
| 7 | a′ | 1489 | 1477 | 1432 | 1420 | 1393 | 1427 | 1349 | 1474 |
| 8 | a′ | 1396 | 1439 | 1390 | 1401 | 1393 | 1398 | 1338 | 1392 |
| 9 | a′ | 1380 | 1374 | 1288 | 1368 | 1363 | 1312 | 1253 | 1346 |
| 10 | a′ | 1324 | 1298 | 1273 | 1274 | 1264 | 1275 | 1210 | 1304 |
| 11 | a′ | 1250 | 1257 | 1235 | 1229 | 1215 | 1217 | 1182 | 1259 |
| 12 | a′ | 1192 | 1251 | 1108 | 1198 | 1180 | 1097 | 1094 | 1199 |
| 13 | a′ | 1185 | 1112 | 1101 | 1093 | 1089 | 1049 | 983 | 1110 |
| 14 | a′ | 1010 | 1071 | 914 | 927 | 912 | 910 | 872 | 1017 |
| 15 | a′ | 881 | 900 | 901 | 915 | 903 | 870 | 828 | 925 |
| 16 | a′ | 808 | 892 | 755 | 777 | 775 | 766 | 733 | 815 |
| 17 | a′ | 766 | 782 | 750 | 755 | 750 | 711 | 691 | 780 |
| 18 | a′ | 602 | 601 | 538 | 569 | 566 | 505 | 488 | 608 |
| 19 | a′ | 506 | 532 | 488 | 514 | 508 | 464 | 486 | 519 |
| 20 | a′ | 682 | 694 | 664 | 679 | 663 | 655 | 614 | 693 |
| 21 | a′ | 665 | 680 | 567 | 629 | 595 | 591 | 567 | 611 |
| 22 | a″ | 734 | 764 | 687 | 736 | 734 | 710 | 682 | 748 |
| 23 | a″ | 717 | 730 | 673 | 698 | 695 | 672 | 669 | 697 |
| 24 | a″ | 429 | 481 | 406 | 444 | 428 | 429 | 414 | 453 |
| 25 | a″ | 414 | 466 | 379 | 425 | 418 | 380 | 353 | 451 |
| 26 | a″ | 379 | 425 | 330 | 369 | 360 | 369 | 349 | 397 |
| 27 | a″ | 349 | 393 | 307 | 308 | 295 | 286 | 261 | 369 |
| 28 | a″ | 307 | 329 | 278 | 281 | 274 | 283 | 246 | 318 |
| 29 | a″ | 127 | 258 | 147 | 196 | 187 | 162 | 152 | 222 |
| 30 | a″ | 92 | 92 | 88 | 94 | 88 | 89 | 81 | 92 |

**Table S10:** Frequencies (in cm-1) of cationic transitions states as computed at the RMP2/aug-cc-pVTZ level of theory.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| NO. | TS12+ | TS13+ | TS18+ | TS34+ | TS24+ | TS45+ | TS56+ | TS67+ |
| 1 | 3388 | 3517 | 3494 | 3713 | 3685 | 3508 | 3838 | 3648 |
| 2 | 3299 | 2080 | 2035 | 2066 | 2078 | 2043 | 2189 | 3089 |
| 3 | 3165 | 3194 | 3189 | 3173 | 3198 | 3200 | 3294 | 3408 |
| 4 | 1676 | 1780 | 1783 | 1649 | 1643 | 1729 | 1743 | 1645 |
| 5 | 1626 | 1720 | 1643 | 1576 | 1577 | 1654 | 1708 | 1564 |
| 6 | 1545 | 1563 | 1572 | 1555 | 1556 | 1591 | 1627 | 1505 |
| 7 | 1424 | 1484 | 1517 | 1459 | 1483 | 1498 | 1504 | 1421 |
| 8 | 1415 | 1436 | 1440 | 1434 | 1452 | 1484 | 1476 | 1392 |
| 9 | 1388 | 1400 | 1413 | 1341 | 1334 | 1384 | 1419 | 1296 |
| 10 | 1320 | 1299 | 1321 | 1277 | 1286 | 1302 | 1354 | 1275 |
| 11 | 1145 | 1260 | 1221 | 1233 | 1244 | 1281 | 1287 | 1227 |
| 12 | 1093 | 1136 | 1187 | 1197 | 1180 | 1200 | 1236 | 1013 |
| 13 | 980 | 1073 | 1091 | 1066 | 1090 | 1076 | 1214 | 1005 |
| 14 | 962 | 951 | 968 | 1004 | 954 | 991 | 1070 | 920 |
| 15 | 940 | 945 | 924 | 949 | 946 | 916 | 1045 | 865 |
| 16 | 763 | 871 | 812 | 826 | 869 | 835 | 843 | 777 |
| 17 | 661 | 720 | 768 | 766 | 747 | 744 | 811 | 734 |
| 18 | 658 | 714 | 695 | 739 | 743 | 709 | 800 | 716 |
| 19 | 594 | 685 | 670 | 667 | 694 | 693 | 729 | 712 |
| 20 | 588 | 673 | 623 | 652 | 674 | 629 | 722 | 631 |
| 21 | 563 | 672 | 612 | 572 | 626 | 617 | 667 | 597 |
| 22 | 495 | 536 | 555 | 557 | 542 | 552 | 611 | 506 |
| 23 | 334 | 452 | 450 | 490 | 484 | 468 | 522 | 437 |
| 24 | 323 | 435 | 395 | 415 | 436 | 400 | 490 | 381 |
| 25 | 317 | 399 | 372 | 404 | 407 | 399 | 404 | 366 |
| 26 | 293 | 312 | 310 | 311 | 303 | 317 | 380 | 285 |
| 27 | 175 | 299 | 299 | 294 | 291 | 307 | 331 | 268 |
| 28 | 159 | 143 | 144 | 166 | 188 | 150 | 241 | 159 |
| 29 | 143 | 110 | 101 | 102 | 99 | 97 | 164 | 82 |
| 30 | i1845 | i1869 | i2015 | i1904 | i1908 | i506 | i1749 | i568 |



**Figure S1:** Outermost molecular orbitals of 5-fluouracil isomers and tautomers.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| **5-FU1** | **5-FU2** | **5-FU3** | **5-FU4** |
|  |  |  |  |
| **5-FU5** | **5-FU6** | **5-FU7** | **5-FU8** |

**Figure S2:** UV-Vis spectra of 5-fluouracil isomers and tautomers.