Supporting information

Six-plex switchable DNA origami cipher disk for tandem-in-time cryptography

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Materials

Single-stranded M13mp18 DNA genome was purchased from Bayou Biolabs, America. All short oligonucleotides were obtained from Sangon Biotech Co. Ltd. (Shanghai, China). AuNP with diameter ~10 nm was bought from Ted Pella, Inc. Tris-(2-carboxyethyl)phosphine (TCEP), magnesium acetate and tris-acetate-EDTA (TAE) buffer were acquired from Aladdin Bio-Chem Technology Co. Ltd. (Shanghai, China).

Preparation of ssDNA modified AuNPs

The 3'-thiolated DNA strands (HS-DNA1 and HS-DNA2, see Table S3 for the detailed sequences of thiolated DNA) were mixed with tris-(2-carboxyethyl)phosphine (TCEP) in ice water for 1.5 h (the ratio of TCEP to DNA at 100:1), and were then purified by size exclusion columns (G-25, GE Healthcare). Subsequently, the thiolated ssDNA was mixed with AuNPs solution (the ratio of DNA to AuNPs at 150 (HS-DNA1):150 (HS-DNA2):1 (AuNPs)) and incubated for 1.5 h. After that, phosphate buffer (10 mM) was added in the solution to age for 1.5 h. In the subsequent salt-aging process, 2.0 M NaCl solution was gradually added to the mixture during six steps at intervals of 1 h until the final concentration of NaCl reached 0.3 M. After 16 h, the unmodified ssDNA were removed by centrifugation at 20000 rcf for 1 h and washed by 0.01 M PBS buffer (10 mM phosphate buffer containing 0.1 M NaCl) for 4 times.

Design, fabrication and purification of Eoct-DOFs

Elongated octahedron DNA origami frame (Eoct-DOF) was designed by caDNAno software (http://cadnano.org/)[1,2]. The frame was fabricated by mixing 10 nM M13mp18 DNA genome, 100 nM staple strands (Table S8), 75 nM anchor strands (including Anchor strands 1, 2, 3 for fixing single AuNP in frame A and Anchor strands 4, 5, 6 in frame B, Table S4), 100 nM sticky end strands and closing end strands (Table S5) in 40 mM tris-acetate, 1.0 mM EDTA, and 12.5 mM magnesium acetate (pH = 8.3 at 23 °C) buffer solution (1 × TAE buffer solution containing 12.5 mM magnesium acetate). The prepared mixture was then processed by the following annealing procedures:

1. 90 °C: 25 sec
2. 90 °C --->85 °C: with rate -0.1 °C / 5 sec

3. 85 °C --->65 °C: with rate -0.1 °C / 30 sec

4. 65 °C --->40 °C: with rate -0.1 °C / 4 min

5. 40 °C --->32 °C: with rate -0.1 °C / 2 min

6. 32 °C --->20 °C: with rate -0.1 °C / 1 min

7. Hold at 20 °C

The prepared DNA origami frame was purified by PEG precipitation according to the literature[3]. Briefly, 20 g PEG lumps (Mw: 8000 g/mol or 10,000 g/mol) were dissolved in 100 mL 2 × TE solution containing 500 mM NaCl for preparation of PEG buffer. The prepared DNA origami sample was mixed with the same account of PEG buffer and was then centrifuged at 14500 rpm for 3 h. After the supernatant was removed, the condensed DNA origami sediment attached at the bottom was mixed with desired buffer solution (1 × TAE, 12.5 mM magnesium acetate) and redispersed at a constant temperature overnight (1000 rpm, 12 h, 37.5 °C).

Assembly of Eoct-DOF dimer and the DOCD

The Eoct-DOF dimer was assembled by mixing equal volume (50 μL) of purified Eoct-DOF A (10 nM) and Eoct-DOF B (10 nM) (see Fig. S4 and Table S5 for the structure design and sequences) in a centrifuge tube, followed by cooling down from 50 °C to 20 °C at the gradient of -0.2 °C/h. The DNA origami cipher disk (DOCD) was obtained by arranging the AuNPs in the prescribed position of Eoct-DOF dimer. Typically, 20 nM closing strands 1-6 were respectively mixed with 5 nM Eoct-DOF dimer at 37 °C for 30 min. Afterwards, ssDNA modified AuNPs were added into the solution with the molar ratio of AuNPs to Eoct-DOF dimer around 2:1. The different spatial distributions of AuNPs in the Eoct-DOF dimer can be adjusted by adding different input strands (the molar ratio of input strands to Eoct-DOF dimer at 6:1) with incubation at 37 °C for 30 min.

Information encryption and decryption by the DOCD

In this work, our designed DNA origami structure can exhibit six distinguishable visible patterns in response to different input DNA strands. By utilizing these programmable DNA origami patterns that can randomly and reversibly switch between each other, we presented a secure cryptography strategy based on six-plex switchable DOCD. By defining each pattern as one specific cipher symbol, we get characters of all capital letters and Arabic numerals with 36 transitions from one cipher symbol to another. In this way, we develop a secure and efficient encrypted communication scheme. The procedure of encrypted communication between the encoder and decoder included the following steps (Fig. S43): 1) The message was first converted into a string of DNA strands by referring to the code book and key book. 2) The obtained DNA strands (10 or 100 μM information strands, see Table S8 for detailed sequences) were assigned to different tubes, marked in sequence and then confidentially sent to the decoder. 3) After the tubes containing information strands were received, these information strands were in order added into the DOCD solution (212.4 μL) containing Eoct-DOF dimer (200 μL 5 nM), closing strands 1-6 (0.4 μL 10 μM for each strand), and ssDNA modified AuNPs (10 μL 200 nM). All the AuNPs were located outside the Eoct-DOF dimer. The first set of information strands (0.6 μL 10 μM for each strand) was added into the DOCD solution with the ratio of information strands to Eoct-DOF dimer at 6:1, and the mixture was incubated at 37 °C for 30 min. 5 μL of the mixture was then pipetted out for the preparation of TEM specimens, before the addition of the second set of information strands (0.9 μL 10 μM for each strand) into the mixture with the molar ratio of information strands to Eoct-DOF dimer at 9:1. In order to ensure a reaction efficiency as high as possible in each step during the chain replacement reaction, the amount of information strands was increased to 1.5 times compared to those added in the previous step. The above processes were repeated until the last set of information strands was added. 4) Finally, a string of cipher symbols was organized in a tandem-in-time format by TEM characterization of the prepared specimens, and 5) converted to plaintext message according to the code book.

Negative-stained TEM characterization

5.0 μL of sample solution was deposited onto a carbon-coated Cu grid (Shunson Electronic Technology Co., LTD (Shenzhen, China)) pretreated with glow discharge (PELCO easiGlow (Ted Pella, Inc.)) and incubated for 5 min. The excessive sample solution was removed by filter paper, after which the sample attached on carbon grid was further washed with water twice. Subsequently, the sample was negatively stained with 5.0 μL of 2% uranyl acetate solution for 15 s. The excess stain solution was immediately wicked away by filter paper, followed by characterization on JEM-2800 TEM operated at 200 kV. The statistical analysis of the yields are obtained from ~150 Eoct-DOF dimers for each prescribed pattern.

Fluorescence monitoring of the space shift of AuNPs in the Eoct-DOF dimer

The space shift of AuNPs in the Eoct-DOF dimer was monitored by real-time fluorescence analysis. Fluorescence measurements were performed on a Hitachi Fluorescence Spectrophotometer F-7000 with a 350 μL quartz colorimetric ware. Monochromator was used for the selection of excitation and emission wavelength in the measurement. Briefly, the Anchor 1, 3, 4 and 6 were replaced by fluorescent FAM-, Cy3-, ROX- and Cy5-grafted Anchor 1, 3, 4 and 6, respectively, in the fabrication process of Eoct-DOF dimer (see Table S7 for the detailed sequences of fluorophore-modified anchor strands). The quadruple fluorophore-labeled DOCD solution for fluorescence measurement were prepared by mixing the obtained Eoct-DOF dimer (200 μL 5 nM) with closing strands 1-6 (0.4 μL 10 μM for each strand) and ssDNA modified AuNPs (10 μL 200 nM). After the information strands "O2 O3" (0.6 μL 10 μM for each strand) were added into the DOCD solution, the mixture was immediately placed into quartz colorimetric ware to monitor the fluorescence intensity of the four fluorophores (λ_{ex}(FAM): 490 nm, λ_{em}(FAM): 520 nm; λ_{ex}(Cy3): 540 nm, λ_{em}(Cy3): 560 nm; λ_{ex}(ROX): 575 nm, λ_{em}(ROX): 600 nm; λ_{ex}(Cy5): 640 nm, λ_{em}(Cy5): 660 nm). To acquire the kinetic data, fluorescence intensity was measured every 5 min. For each time point, it is necessary to manually switch the excitation and emission wavelength of the fluorescence spectrophotometer to record the intensities of four fluorophores in turn (each switching time around 5 s). After 30 min, the second set of information strands "O1 C3" (0.9 μL 10 μM for each strand) were added into the mixture with the molar ratio of information strands to Eoct-DOF dimer at 9:1. The next set of information strands were added after another 30 min until addition of all information strands was completed. The amount of information strands was increased to 1.5 times compare to those added in the previous step. The volume change in each step was shown in Table S2.

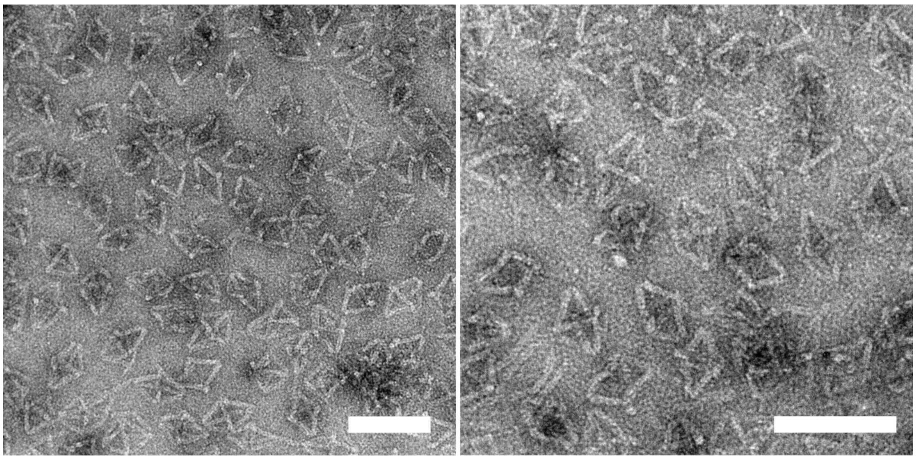

Fig. S1. The representative negative-stained TEM images of Eoct-DOFs. Scale bar: 100 nm.

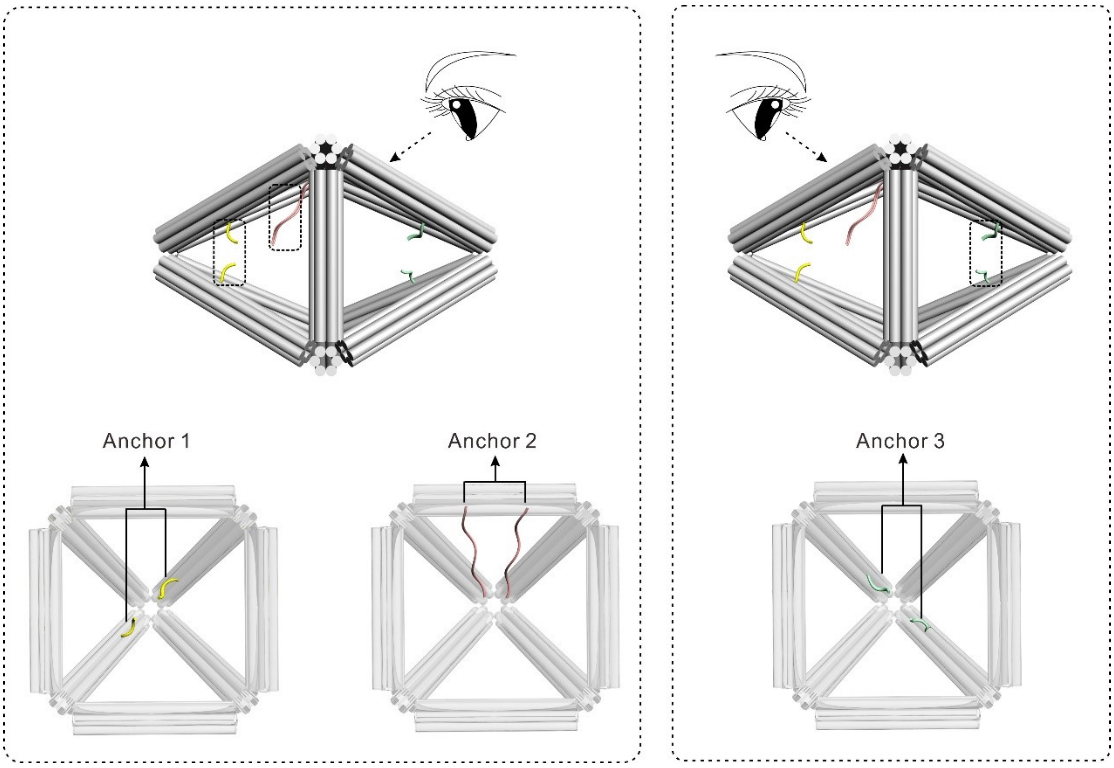

Fig. S2. The schematic position of three sets of anchor strands (Anchor 1, Anchor 2 and Anchor 3) extending from the edges to the interior of frame.

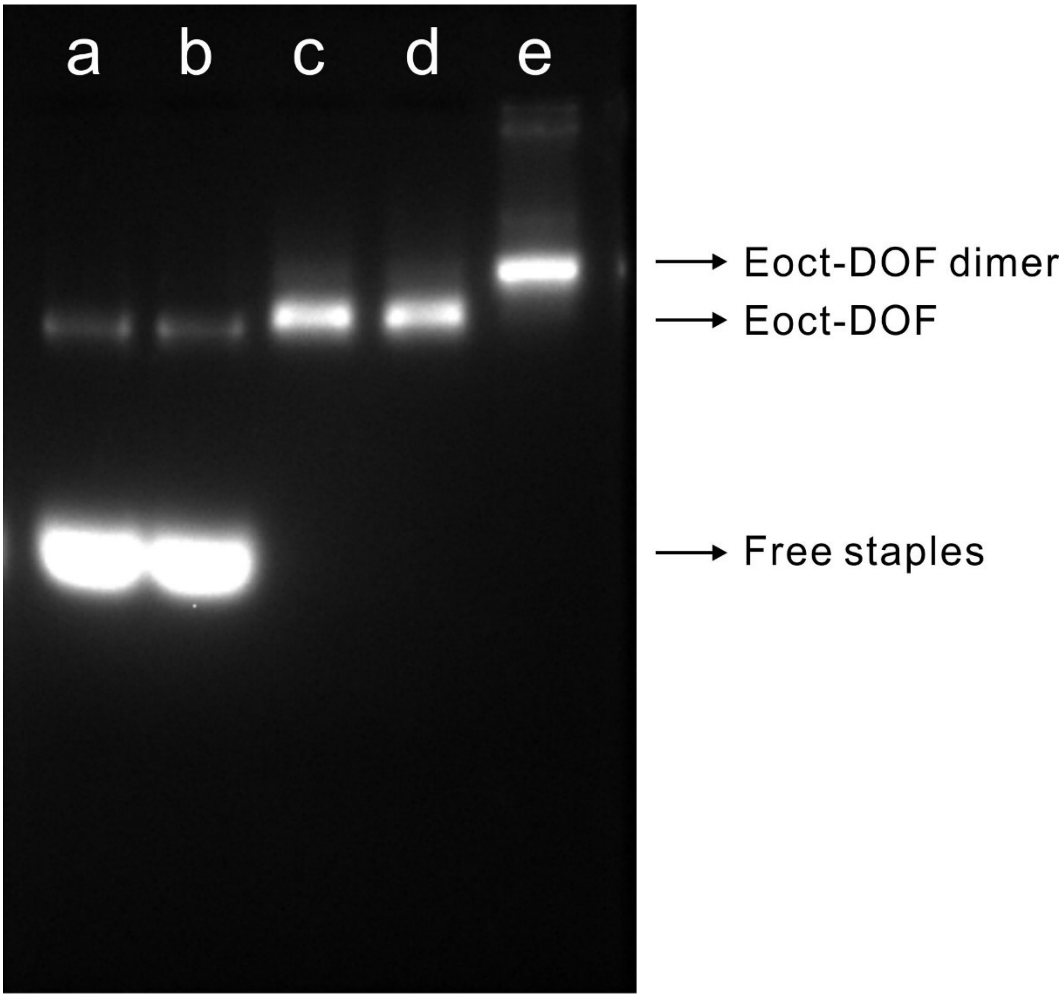

Fig. S3. 1% agarose gel image under UV light for Eoct-DOF A (a), Eoct-DOF B (b), PEG purified Eoct-DOF A (c), PEG purified Eoct-DOF B (d), and Eoct-DOF dimer (e).

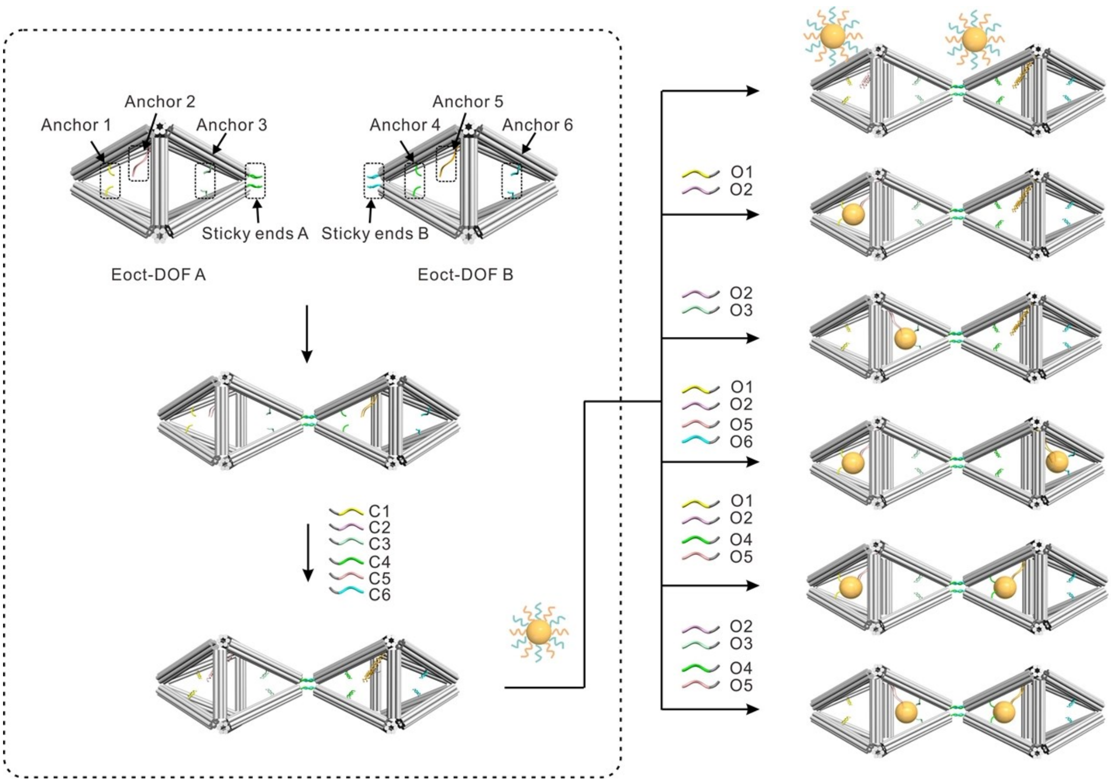

Fig. S4. Construction of the Eoct-DOF dimer and the six kinds of spatial distributions of AuNPs in the Eoct-DOF dimer in response to different input strands.

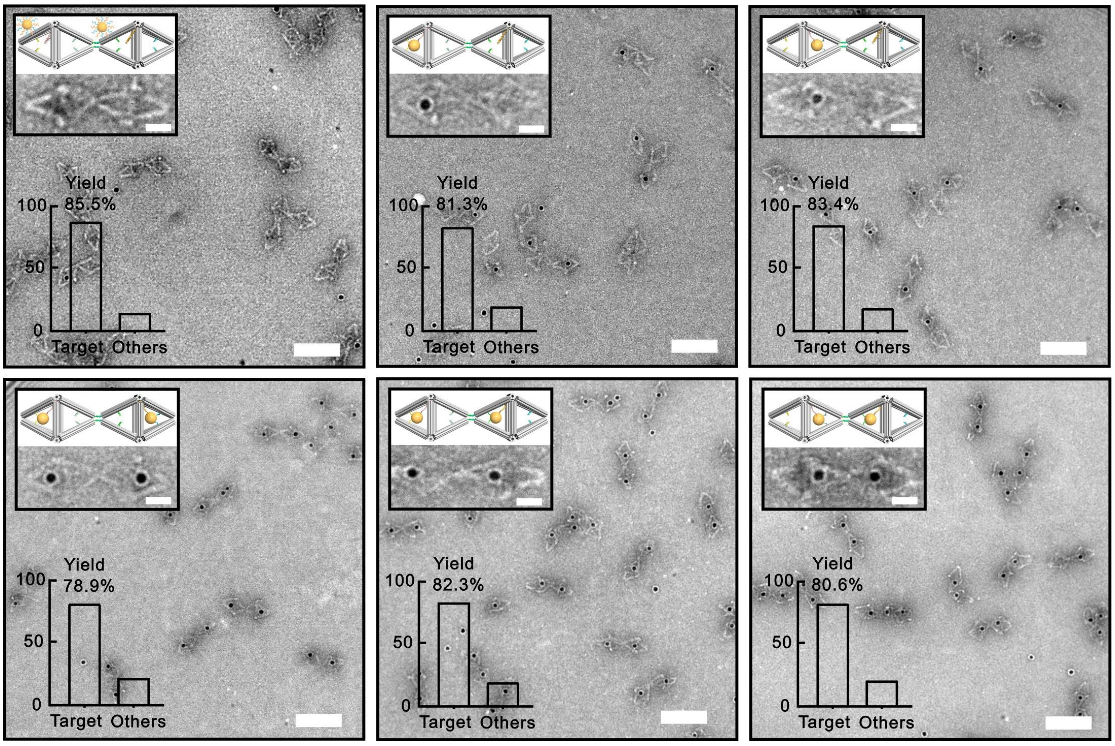

Fig. S5. The representative negative-stained TEM images of six switchable patterns of the DOCD. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm (inset: 20 nm).

Code book:

− → − = "A"	− → + = "B"	− → ○ = "C"	− → ⊖ = "D"	− → ⦶ = "E"	− → ⊕ = "F"
+ → − = "G"	+ → + = "H"	+ → ○ = "I"	+ → ⊖ = "J"	+ → ⦶ = "K"	+ → ⊕ = "L"
○ → − = "M"	○ → + = "N"	○ → ○ = "O"	○ → ⊖ = "P"	○ → ⦶ = "Q"	○ → ⊕ = "R"
⊖ → − = "S"	⊖ → + = "T"	⊖ → ○ = "U"	⊖ → ⊖ = "V"	⊖ → ⦶ = "W"	⊖ → ⊕ = "X"
⦶ → − = "Y"	⦶ → + = "Z"	⦶ → ○ = "0"	⦶ → ⊖ = "1"	⦶ → ⦶ = "2"	⦶ → ⊕ = "3"
⊕ → − = "4"	⊕ → + = "5"	⊕ → ○ = "6"	⊕ → ⊖ = "7"	⊕ → ⦶ = "8"	⊕ → ⊕ = "9"

Key book:

−	+	○	⊖	⦶	⊕	
U	C1 C2	C2 C3	C1 C2 C5 C6	C1 C2 C4 C5	C2 C3 C4 C5	−
O1 O2	U	O1 C3	C5 C6	C4 C5	O1 C3 C4 C5	+
O2 O3	C1 O3	U	C1 O3 C5 C6	C1 O3 C4 C5	C4 C5	○
O1 O2 O5 O6	O5 O6	O1 C3 O5 O6	U	C4 O6	O1 C3 C4 O6	⊖
O1 O2 O4 O5	O4 O5	O1 C3 O4 O5	O4 C6	U	O1 C3	⦶
O2 O3 O4 O5	C1O3 O4 O5	O4 O5	C1 O3 O4 C6	C1 O3	U	⊕

U → Poly T

O → Opening strand

C → Closing strand

Fig. S6. The code book defining the transition of cipher symbols as 36 characters and the key book indicating the information strands required for each transition. For example, accomplishment of the transition "+ →− " requires the addition of the information strands "C1 C2".

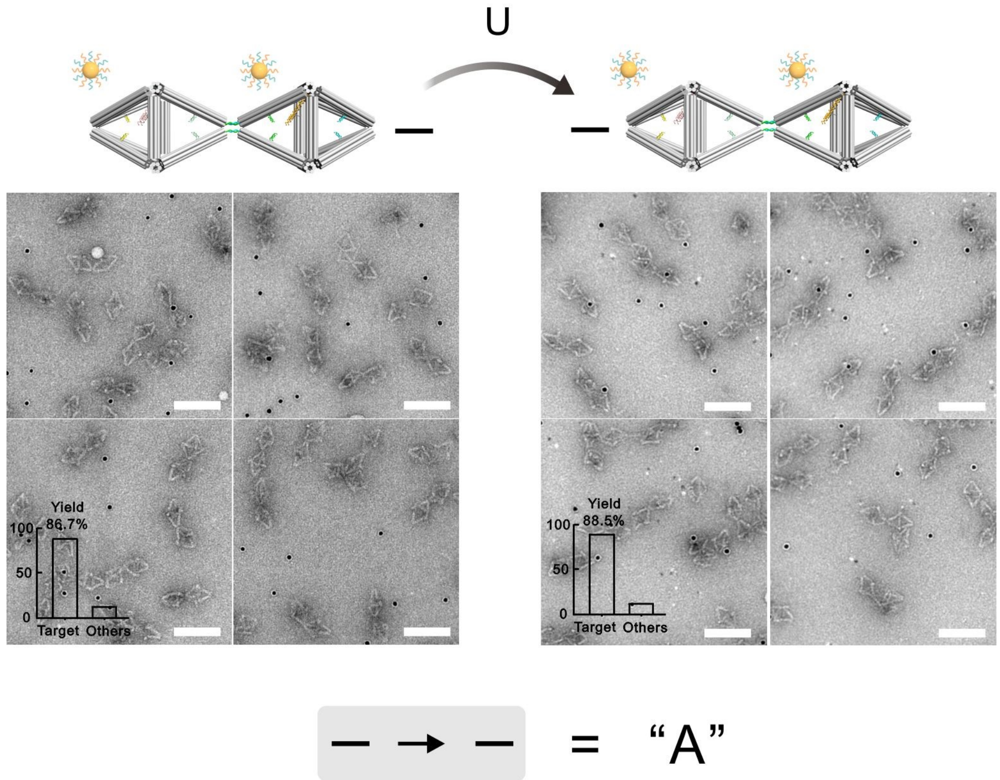

Fig. S7. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "— →— " activated by information strand "U" for exporting the letter "A". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

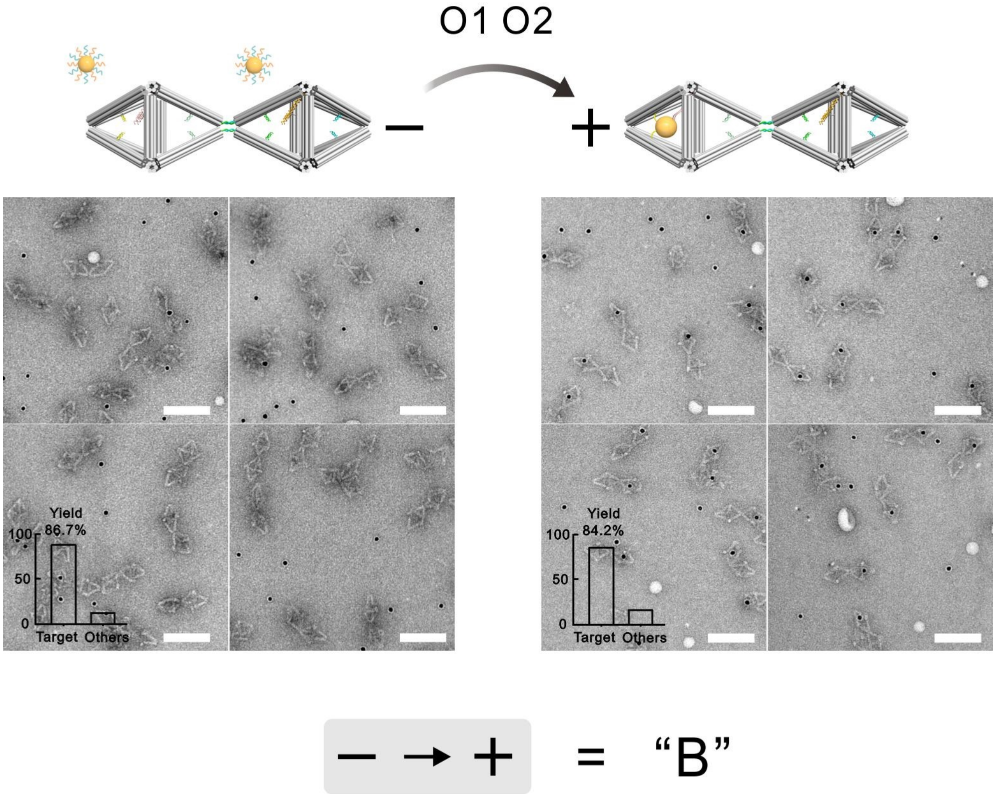

Fig. S8. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “− →+ ” activated by information strands “O1 O2” for exporting the letter “B”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

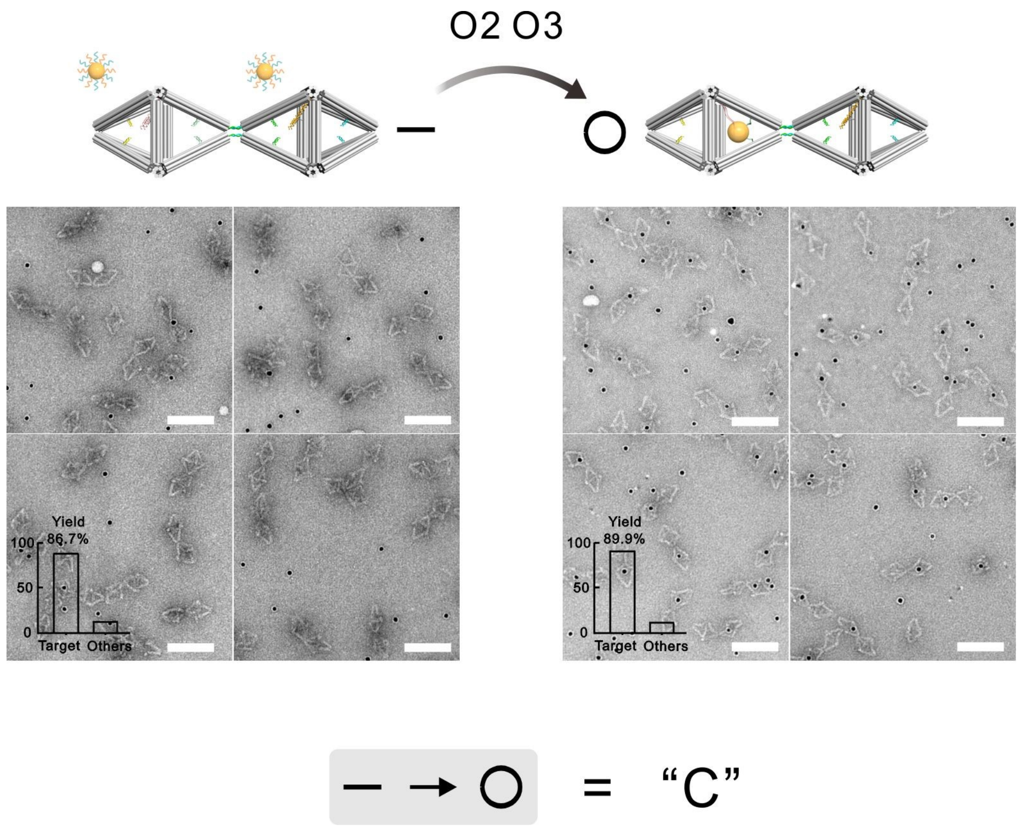

Fig. S9. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "− →○ " activated by information strands "O2 O3" for exporting the letter "C". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

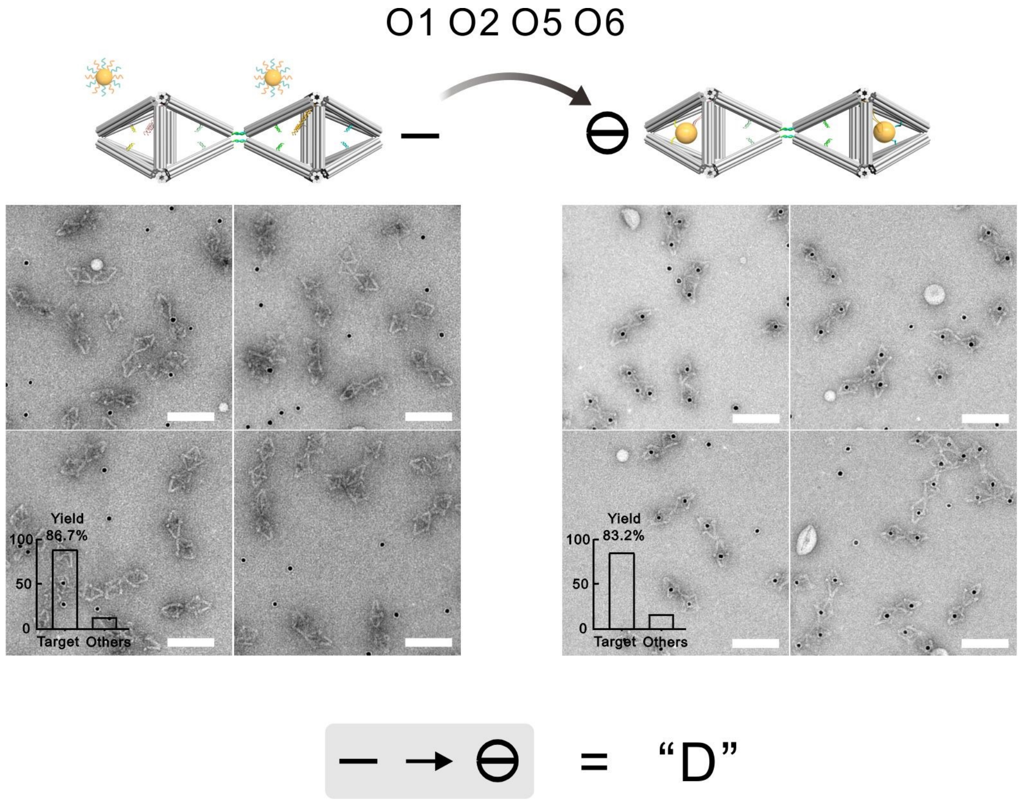

Fig. S10. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "− →⊖" activated by information strands "O1 O2 O5 O6" for exporting the letter "D". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

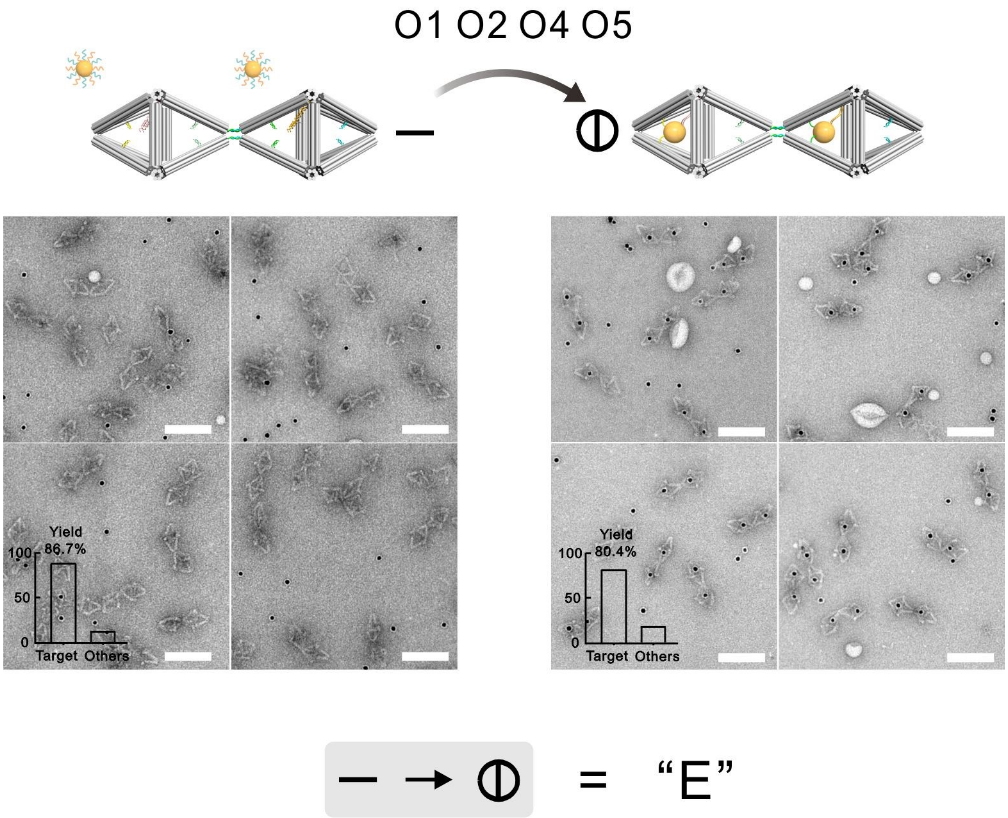

Fig. S11. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “− →⦶ ” activated by information strands “O1 O2 O4 O5” for exporting the letter “E”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

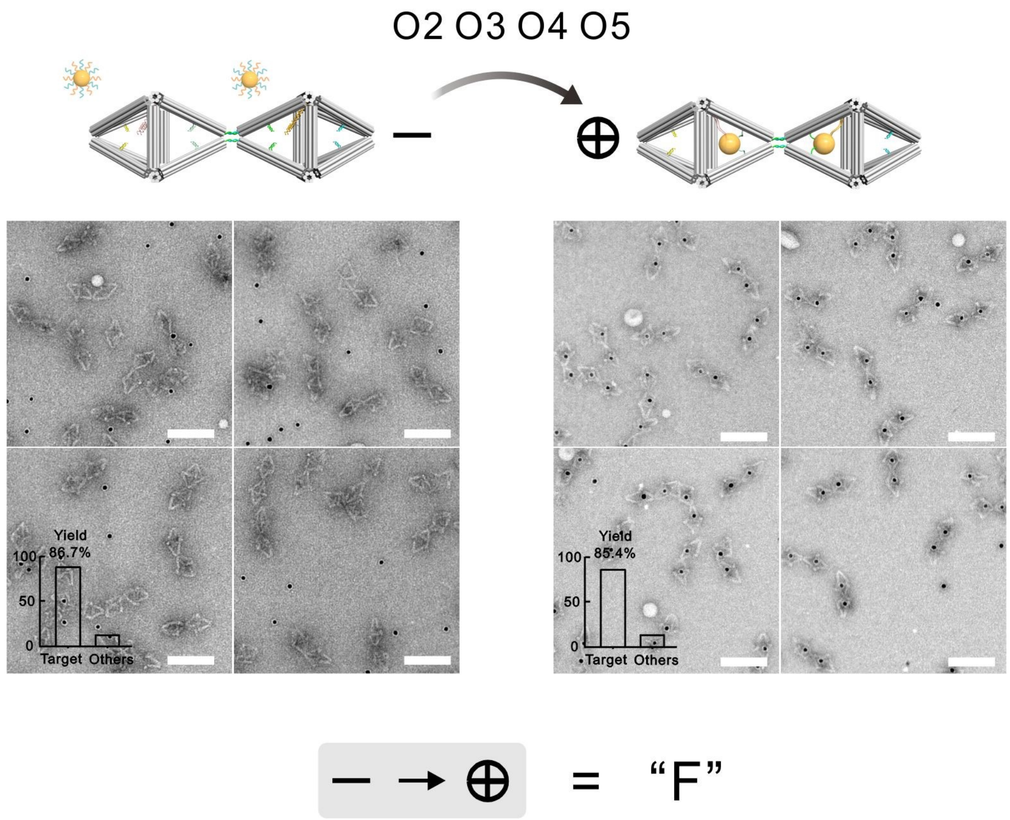

Fig. S12. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "− →⊕" activated by information strands "O2 O3 O4 O5" for exporting the letter "F". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

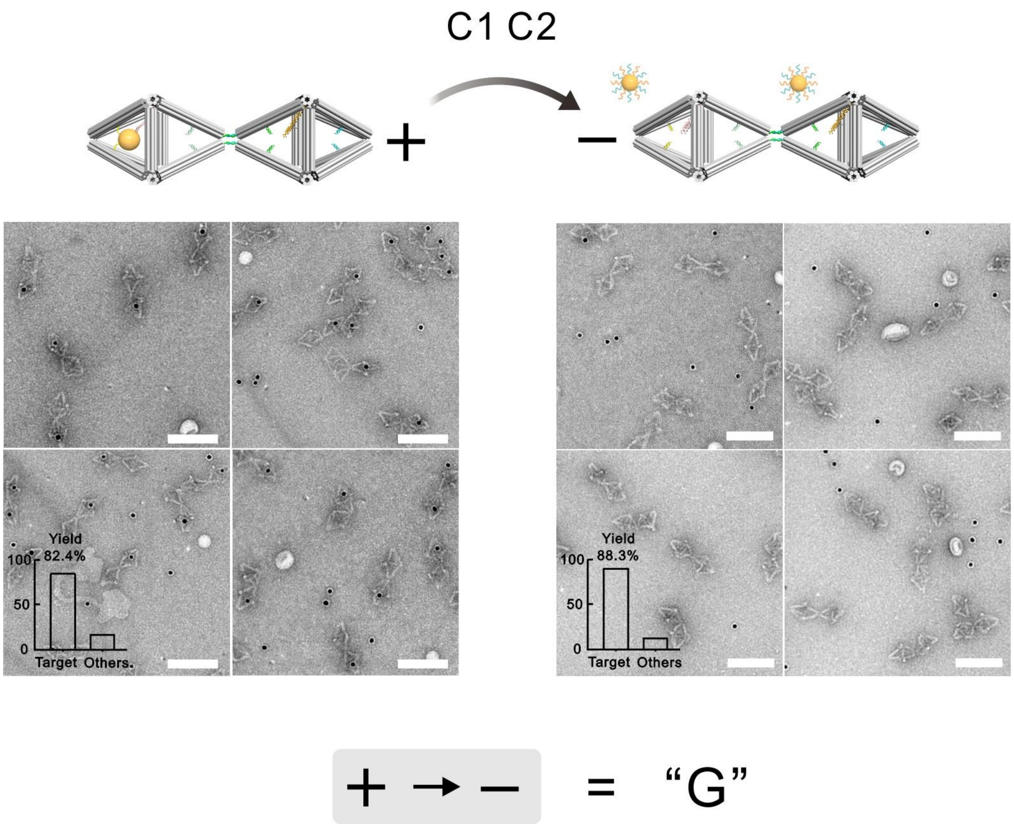

Fig. S13. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "+ →− " activated by information strands "C1 C2" for exporting the letter "G". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

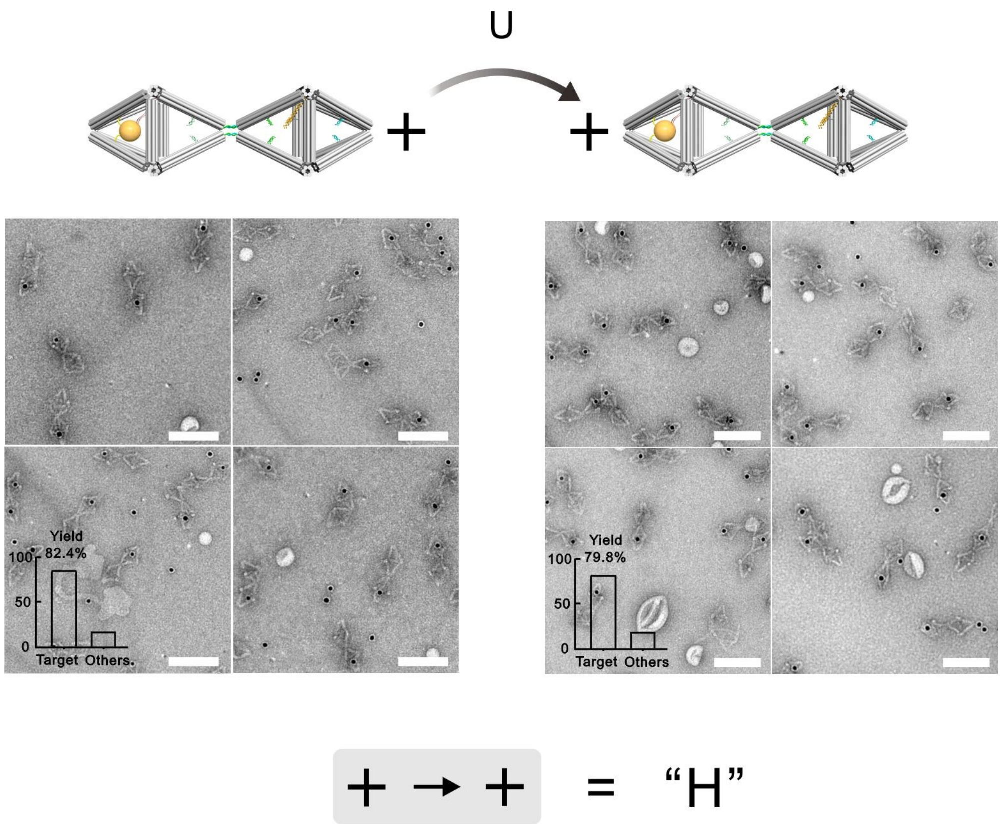

Fig. S14. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "+ →+ " activated by information strand "U" for exporting the letter "H". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

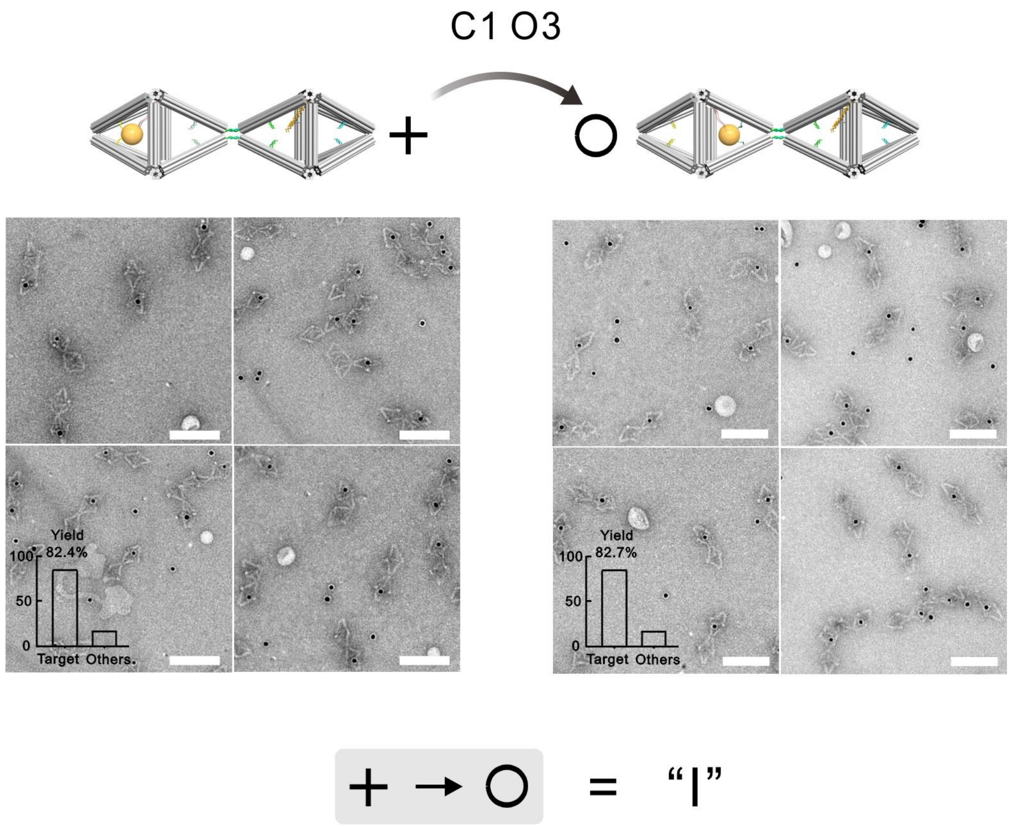

Fig. S15. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “+ →○ ” activated by information strands “C1 O3” for exporting the letter “I”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

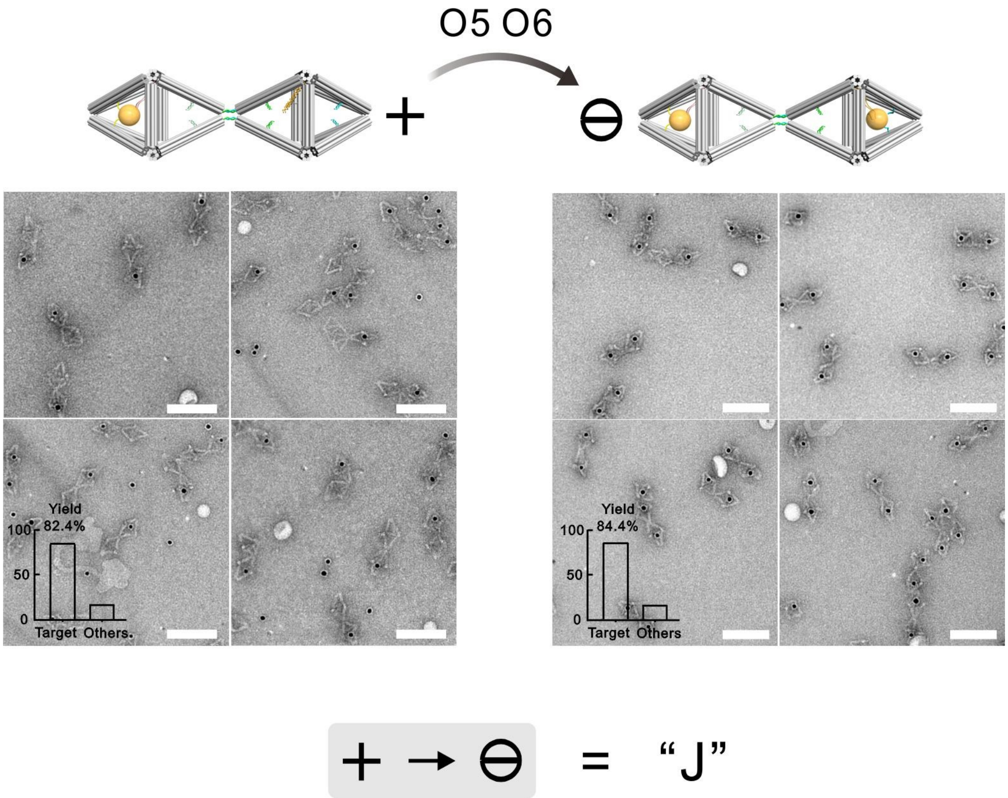

Fig. S16. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "+ →⊖" activated by information strands "O5 O6" for exporting the letter "J". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

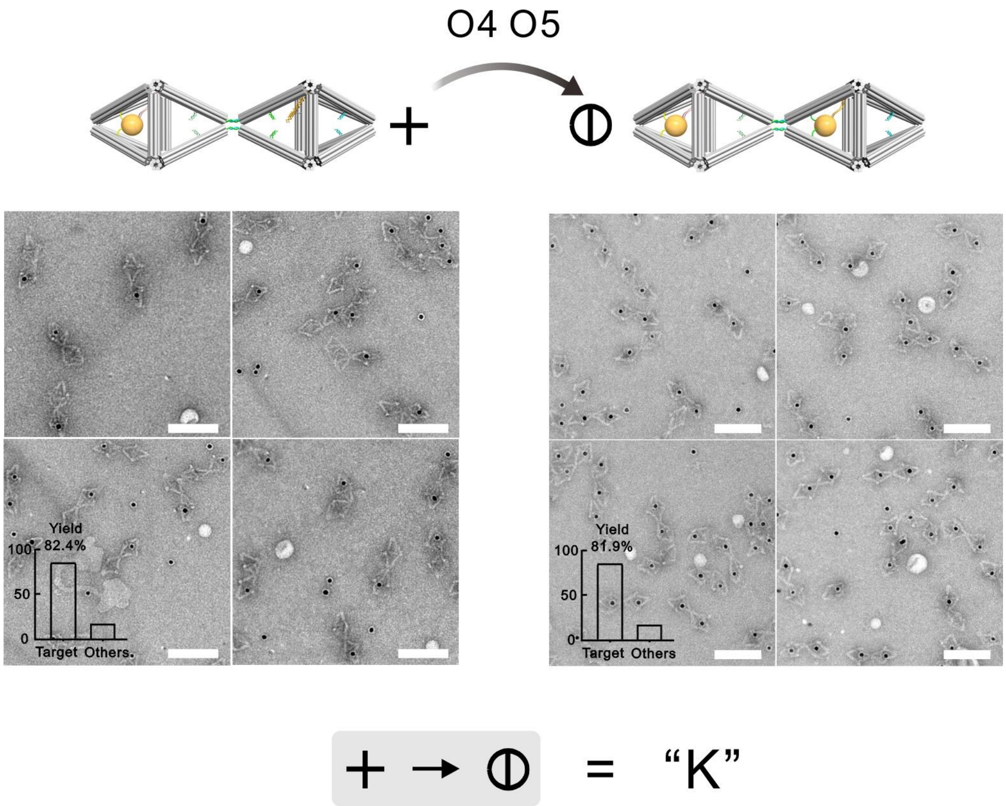

Fig. S17. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "+ →⦶ " activated by information strands "O4 O5" for exporting the letter "K". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

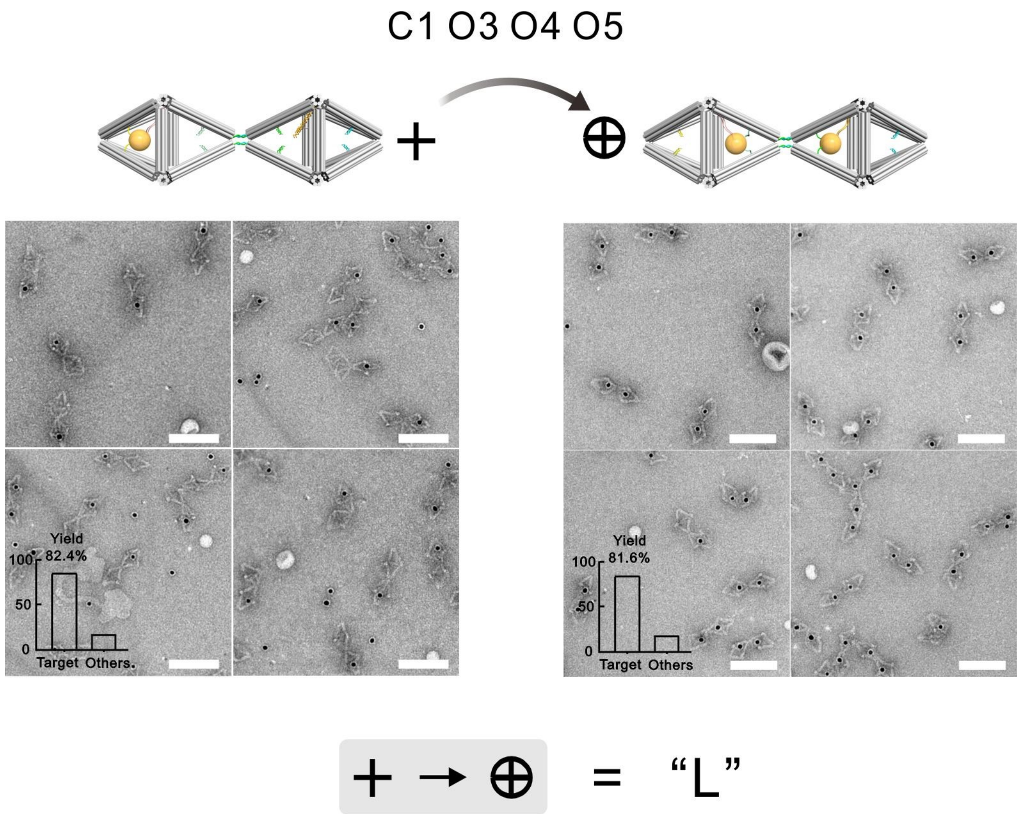

Fig. S18. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "+ →⊕" activated by information strands "C1 O3 O4 O5" for exporting the letter "L". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

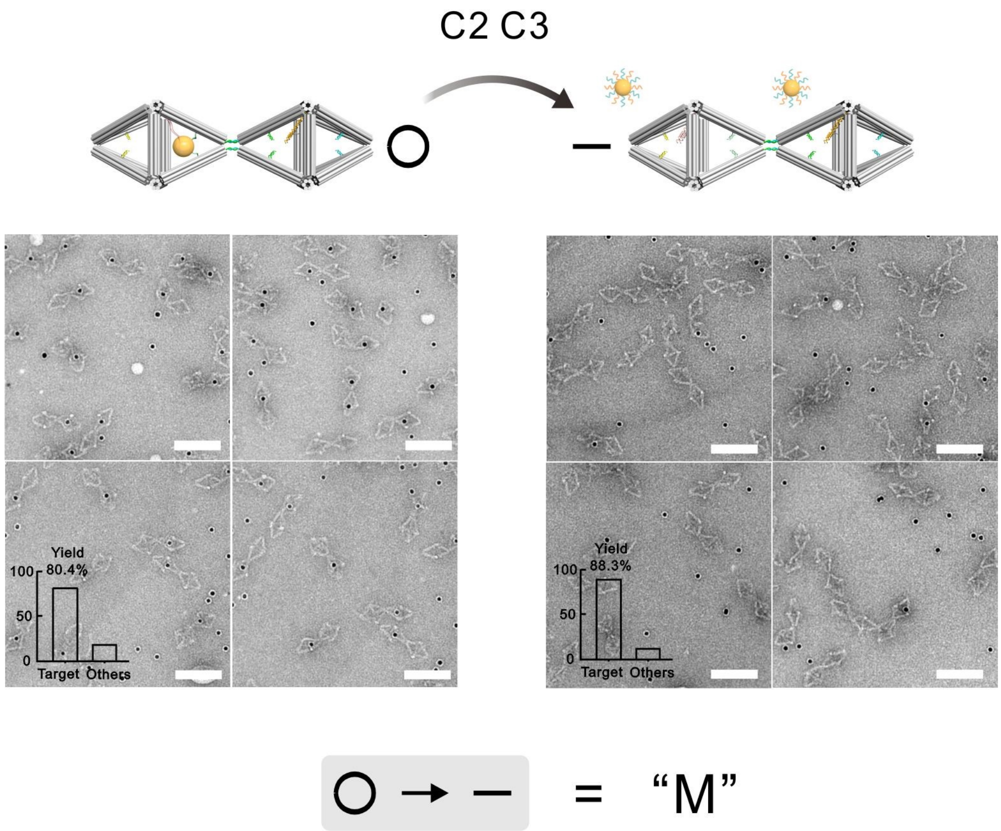

Fig. S19. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “○ →− ” activated by information strands “C2 C3” for exporting the letter “M”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

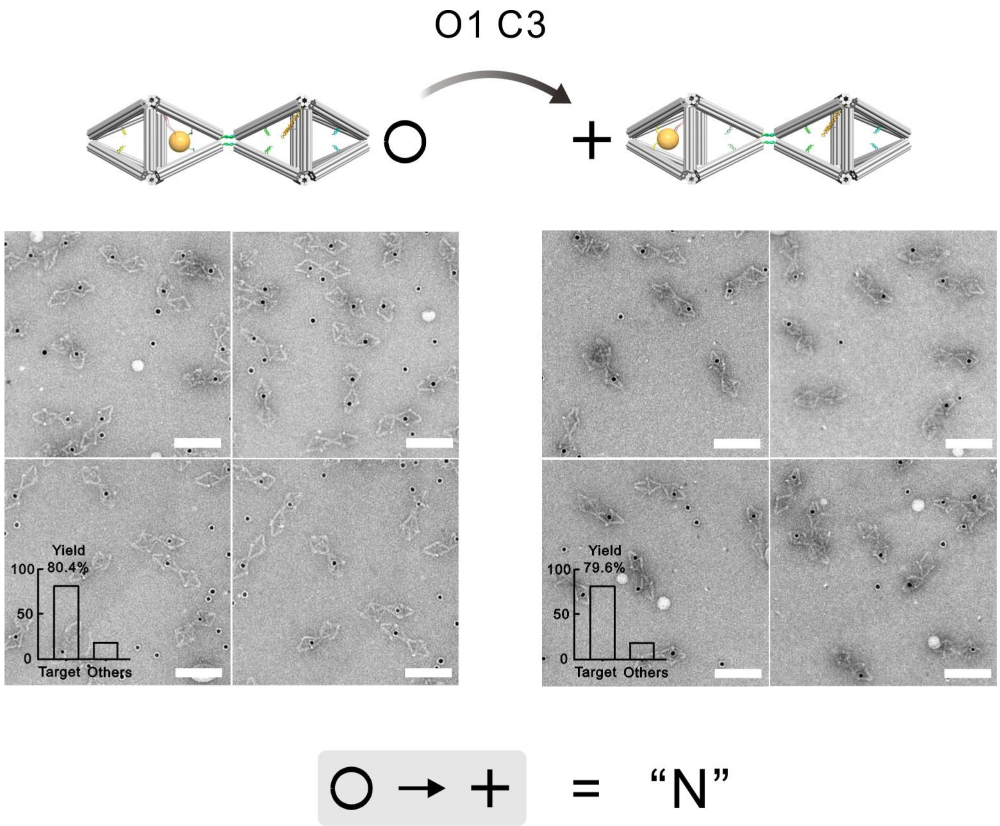

Fig. S20. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "○ →+ " activated by information strands "O1 C3" for exporting the letter "N". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

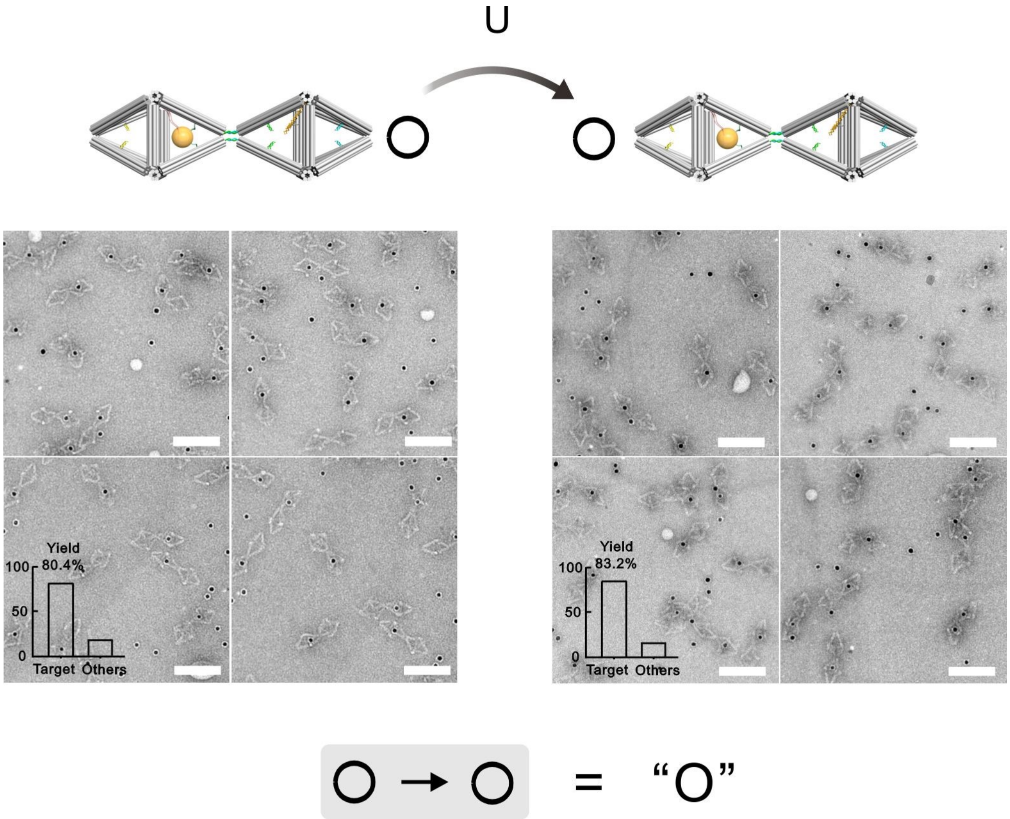

Fig. S21. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "○ →○ " activated by information strand "U" for exporting the letter "O". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

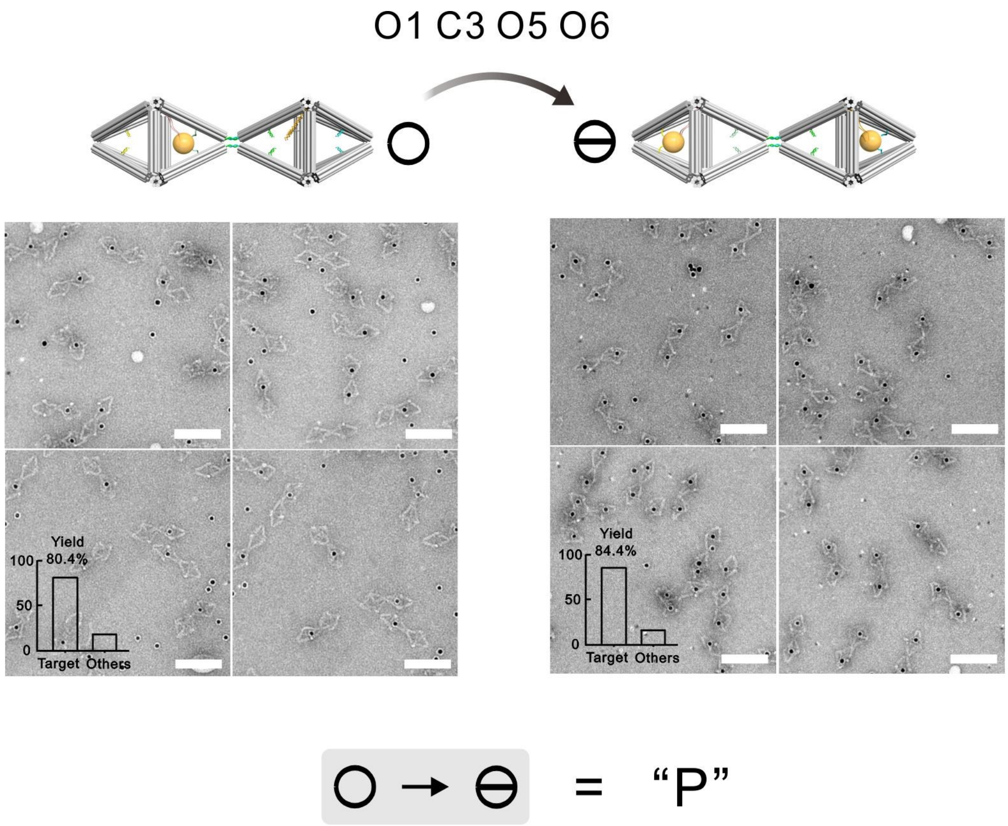

Fig. S22. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "○ →⊖" activated by information strands "O1 C3 O5 O6" for exporting the letter "P". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

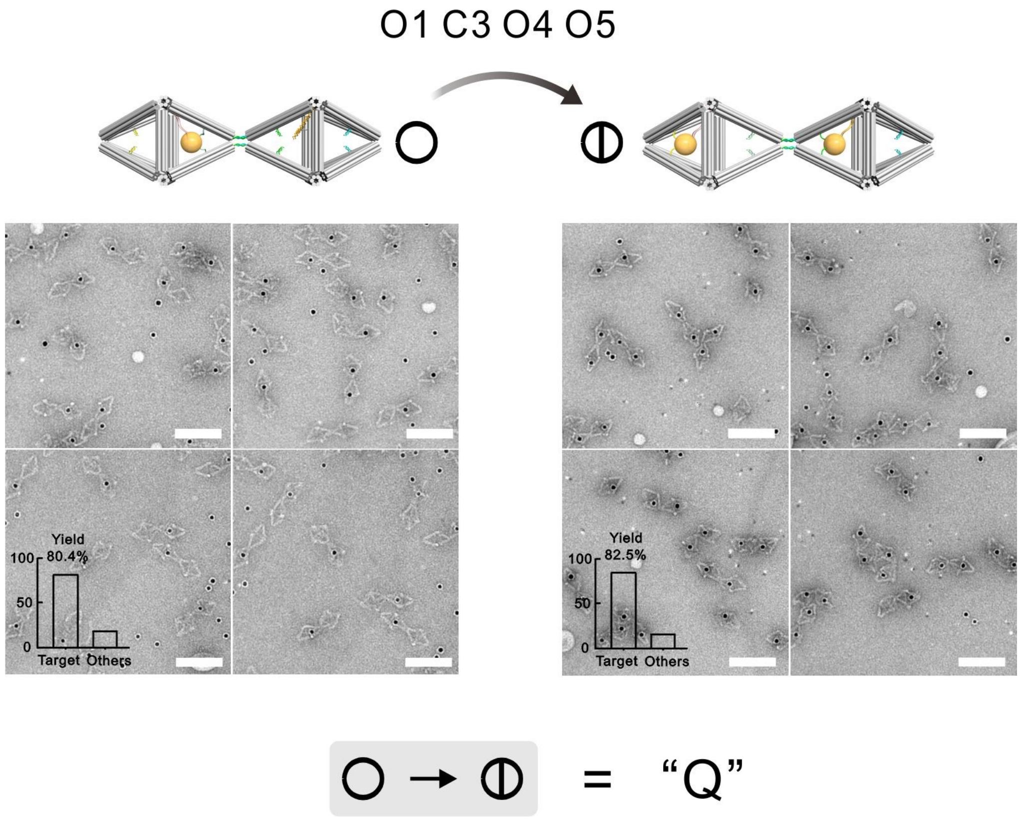

Fig. S23. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “◯ →⦶ ” activated by information strands “O1 C3 O4 O5” for exporting the letter “Q”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

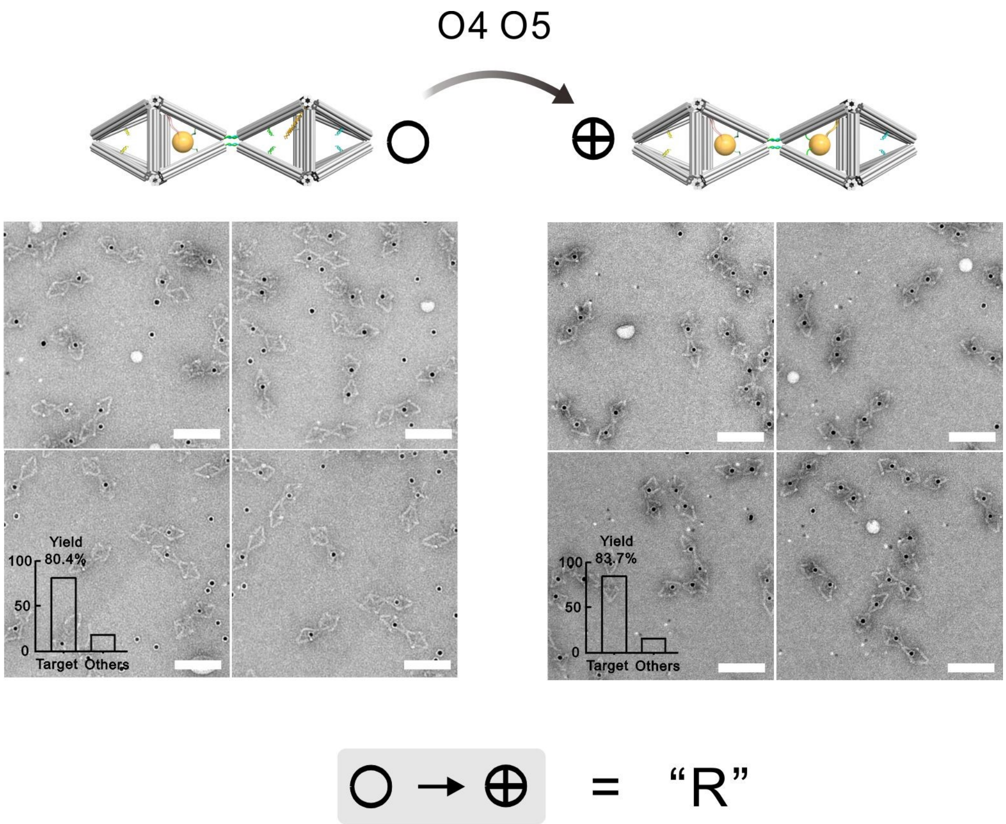

Fig. S24. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "◯ →⊕" activated by information strands "O4 O5" for exporting the letter "R". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

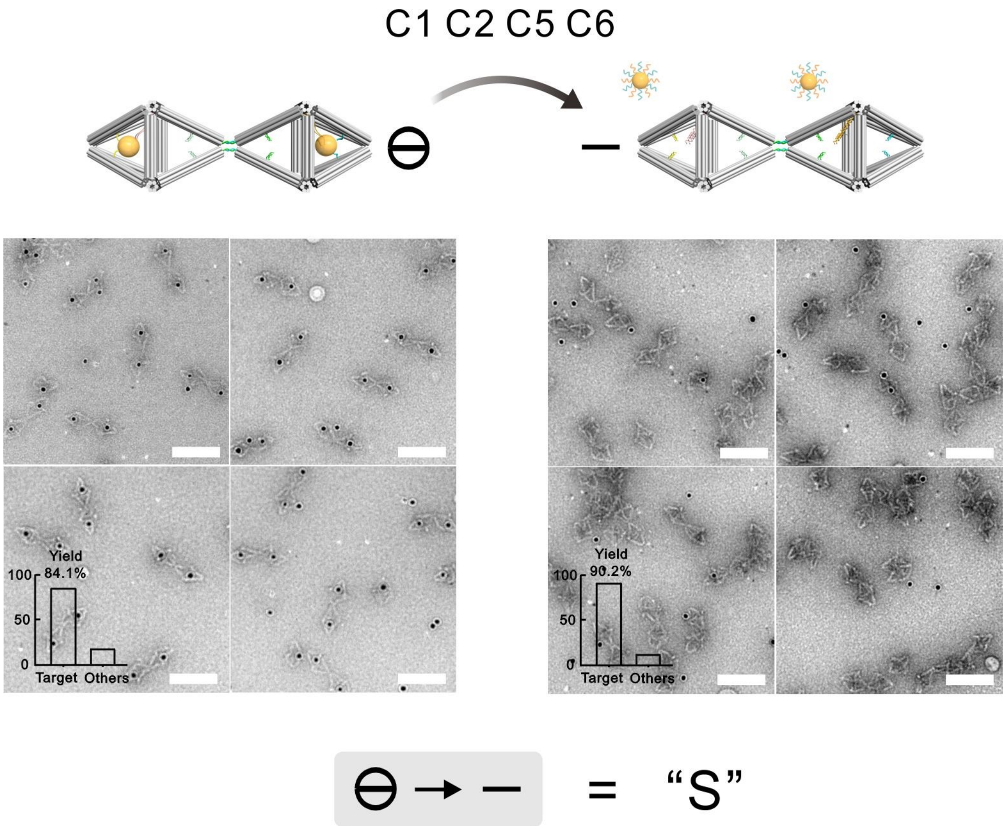

Fig. S25. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⊖→− " activated by information strands "C1 C2 C5 C6" for exporting the letter "S". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

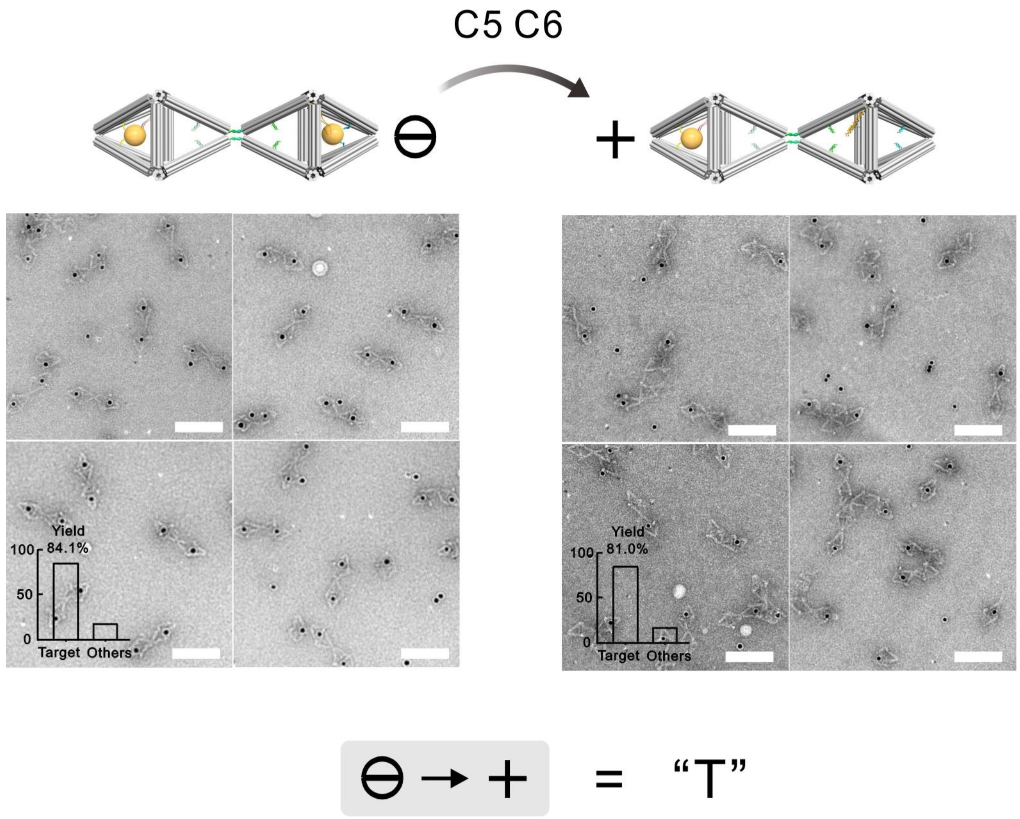

Fig. S26. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⊖→+ " activated by information strands "C5 C6" for exporting the letter "T". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

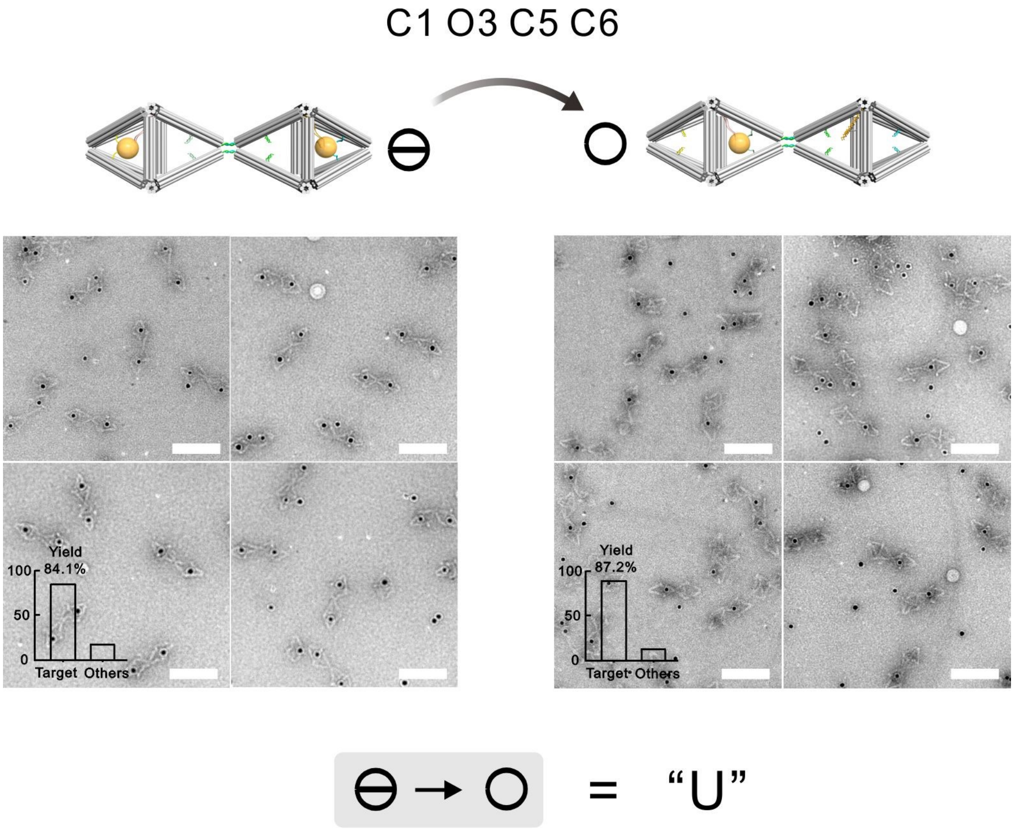

Fig. S27. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⊖→○ " activated by information strands "C1 O3 C5 C6" for exporting the letter "U". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

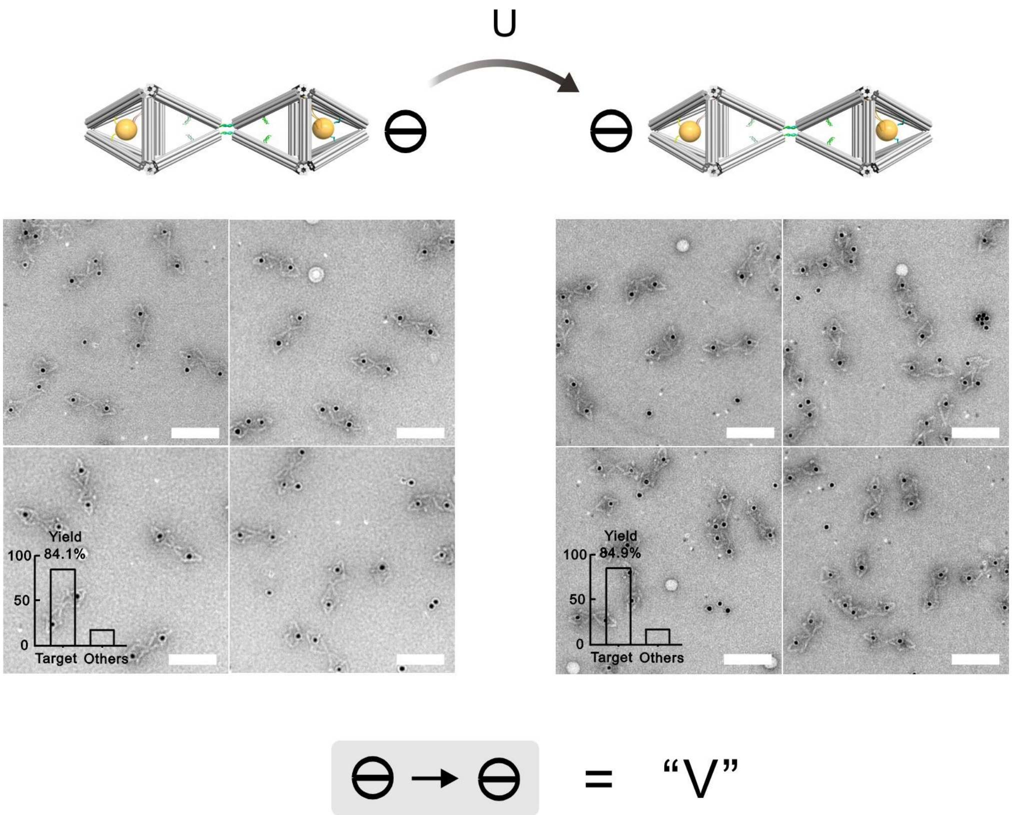

Fig. S28. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “⊖→⊖” activated by information strand “U” for exporting the letter “V”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

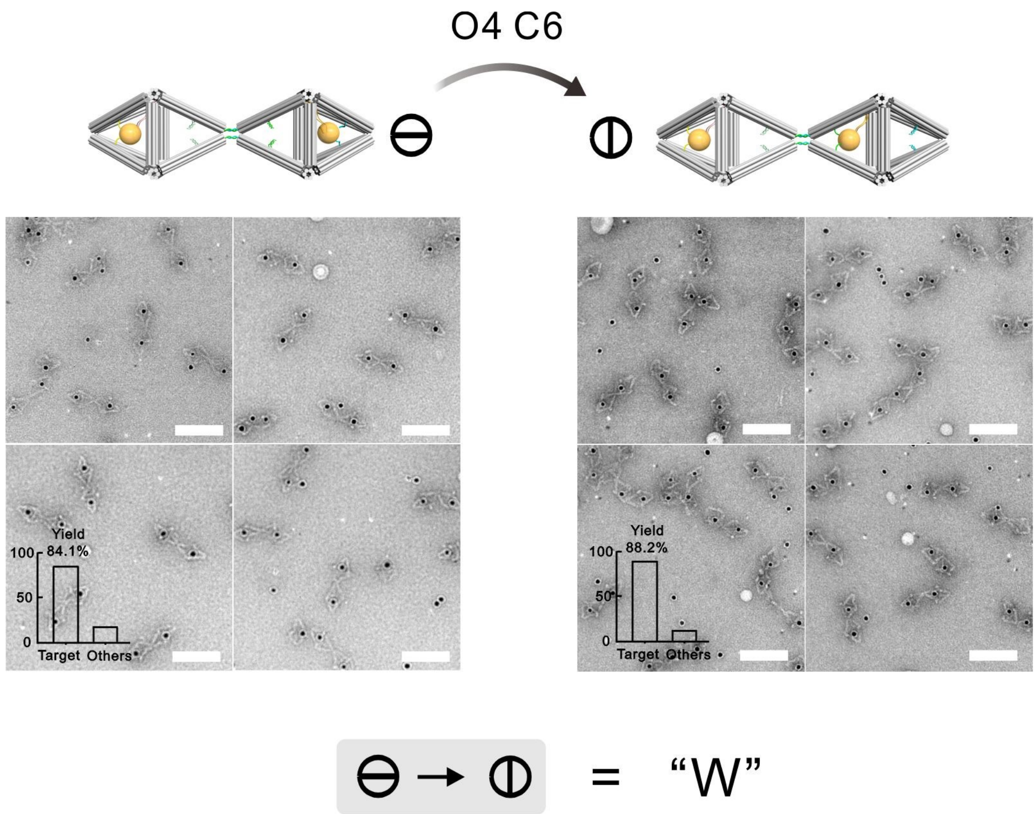

Fig. S29. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⊖→⦶ " activated by information strands "O4 C6" for exporting the letter "W". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

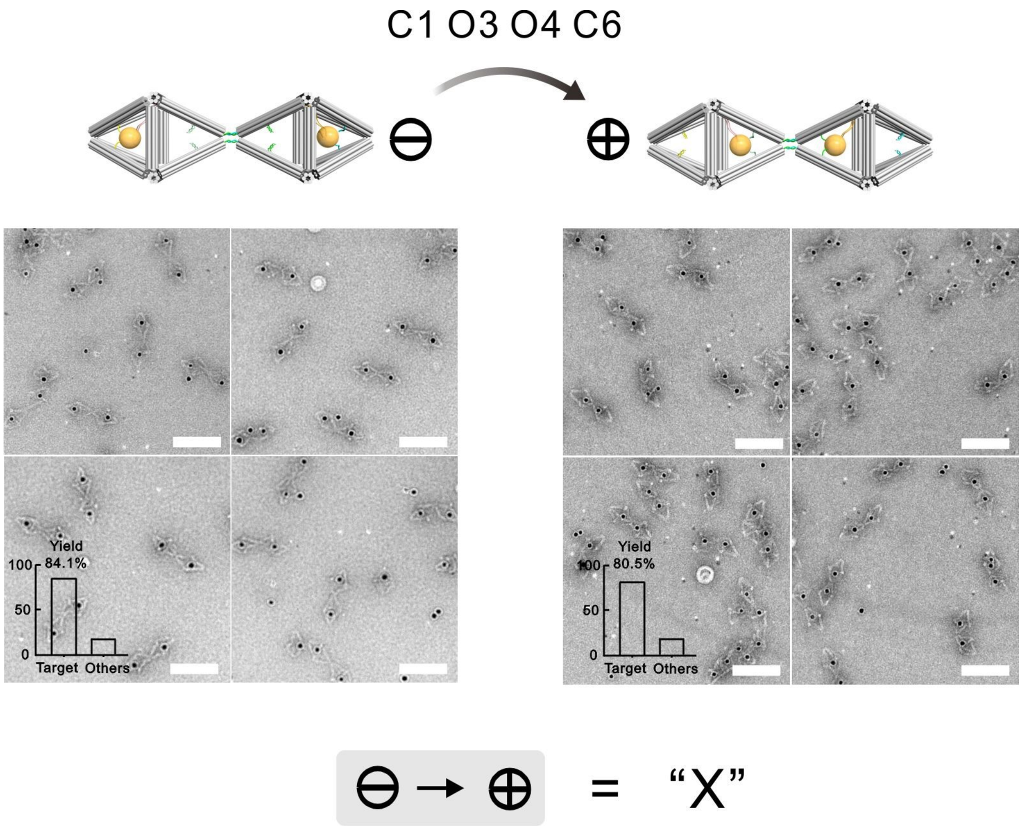

Fig. S30. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⊖→⊕" activated by information strands "C1 O3 O4 C6" for exporting the letter "X". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

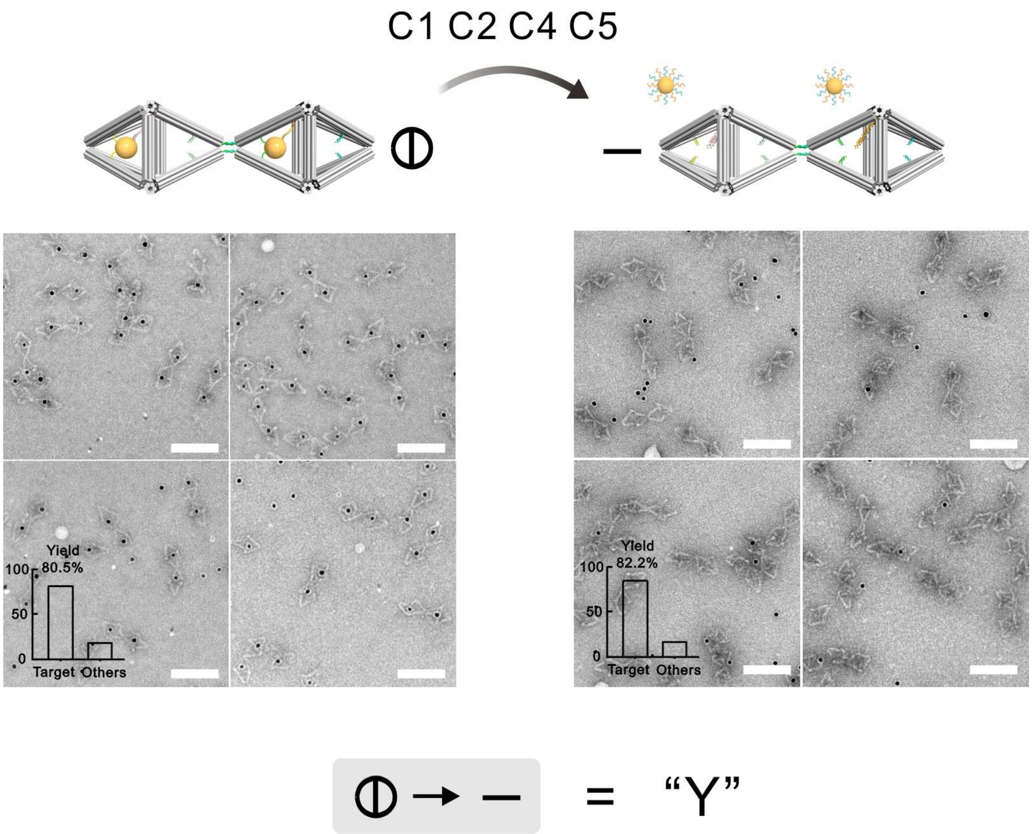

Fig. S31. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⏀ →− " activated by information strands "C1 C2 C4 C5" for exporting the letter "Y". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

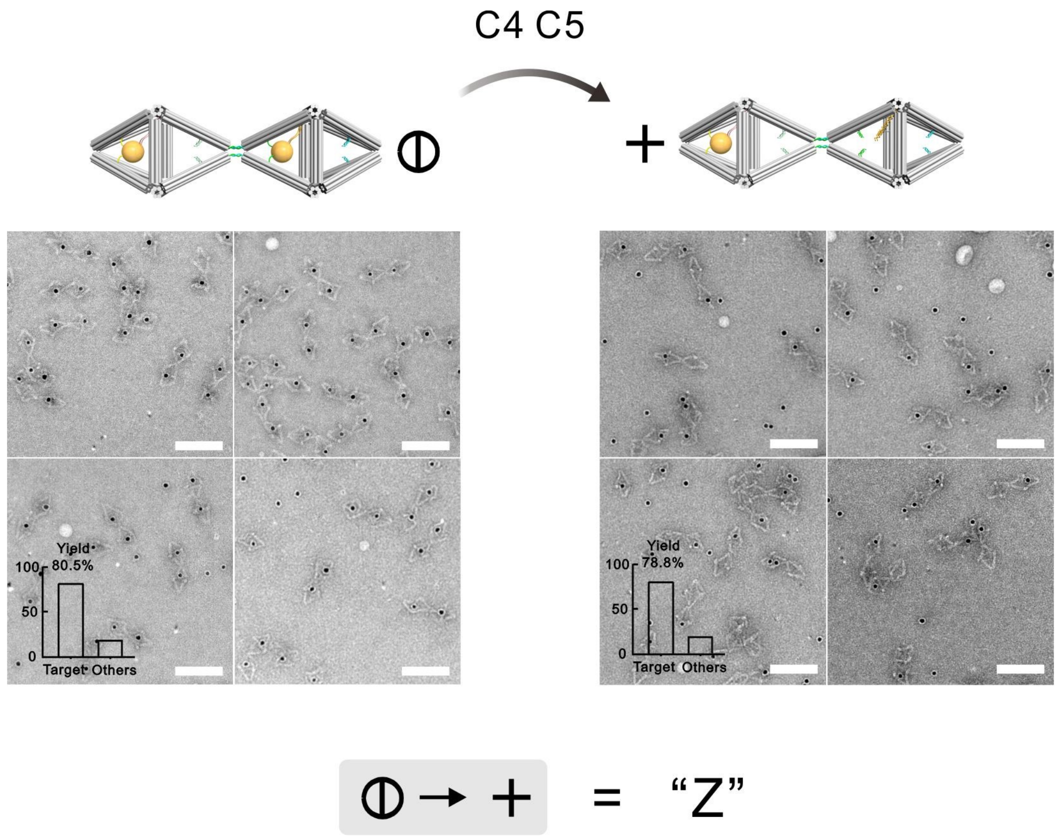

Fig. S32. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “⦶ →+ ” activated by information strands “C4 C5” for exporting the letter “Z”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

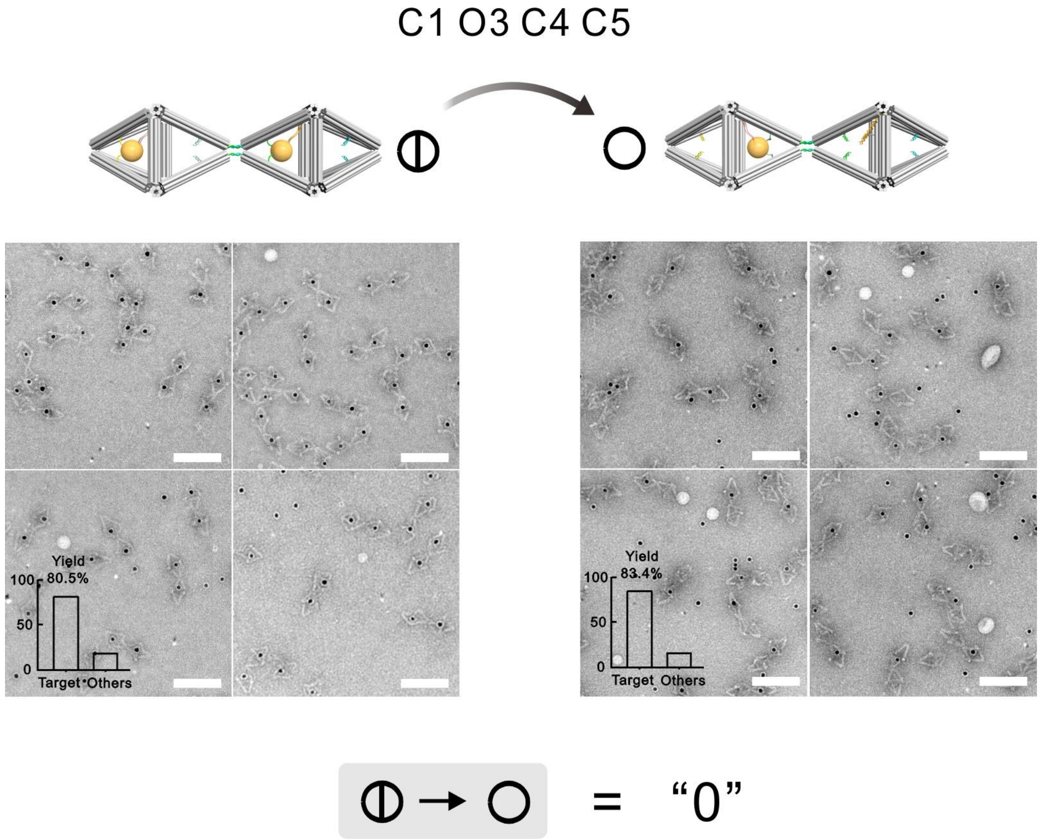

Fig. S33. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⦶ →◯ " activated by information strands "C1 O3 C4 C5" for exporting the Arabic numeral "0". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

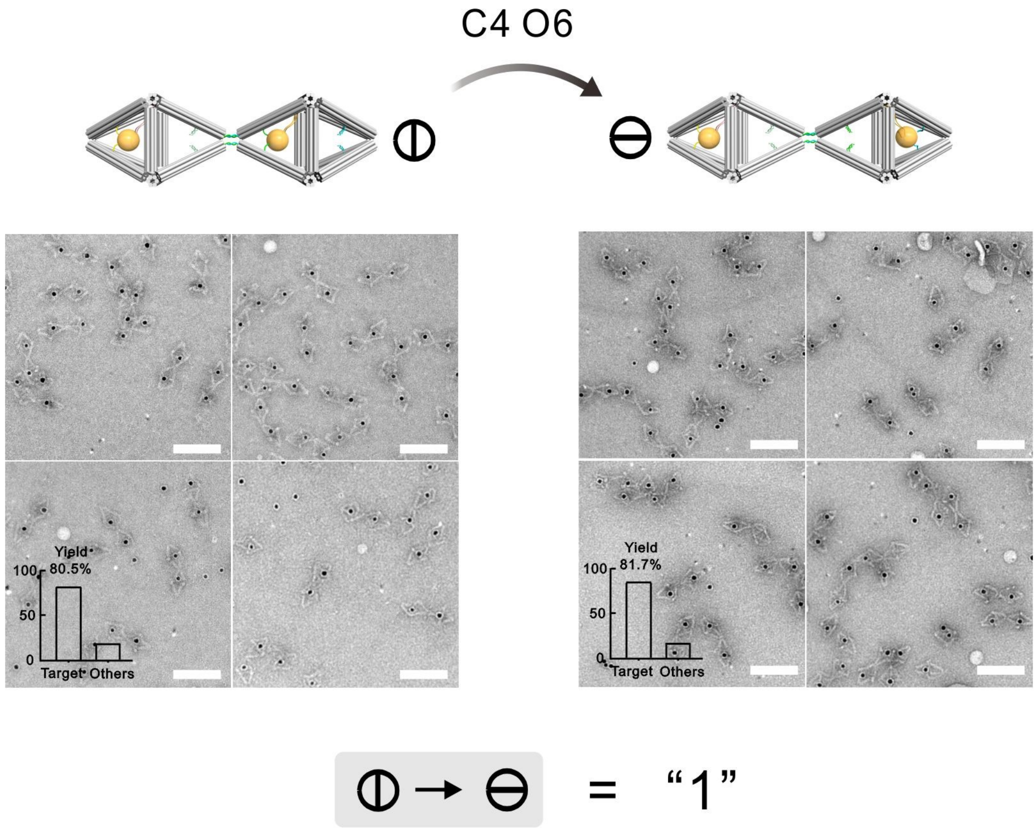

Fig. S34. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “⦶ →⊖” activated by information strands “C4 O6” for exporting the Arabic numeral “1”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

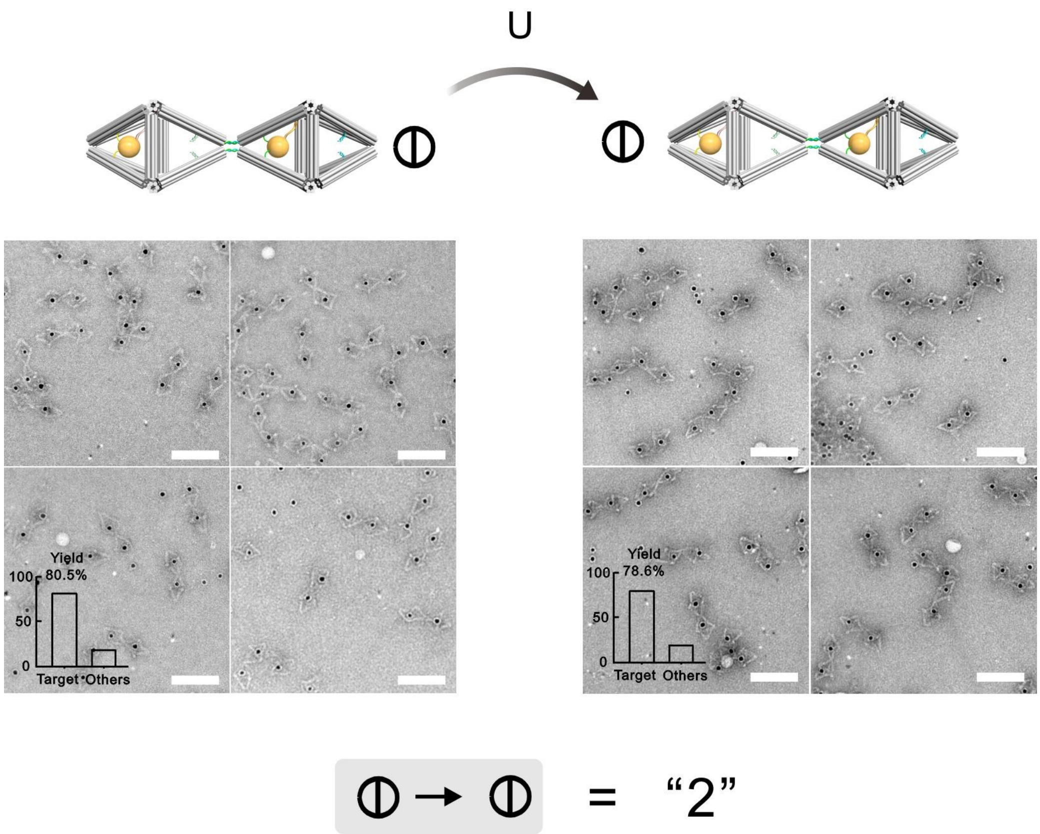

Fig. S35. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⦶ →⦶ " activated by information strand "U" for exporting the Arabic numeral "2". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

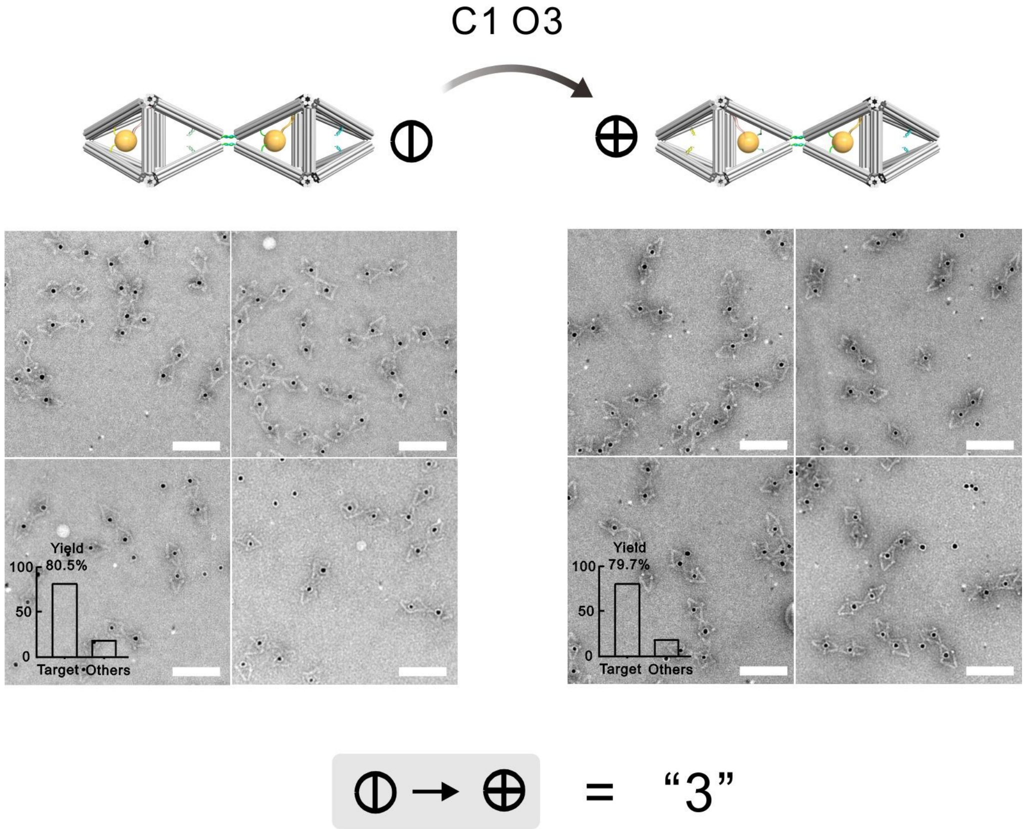

Fig. S36. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⦶ →⊕" activated by information strands "C1 O3" for exporting the Arabic numeral "3". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

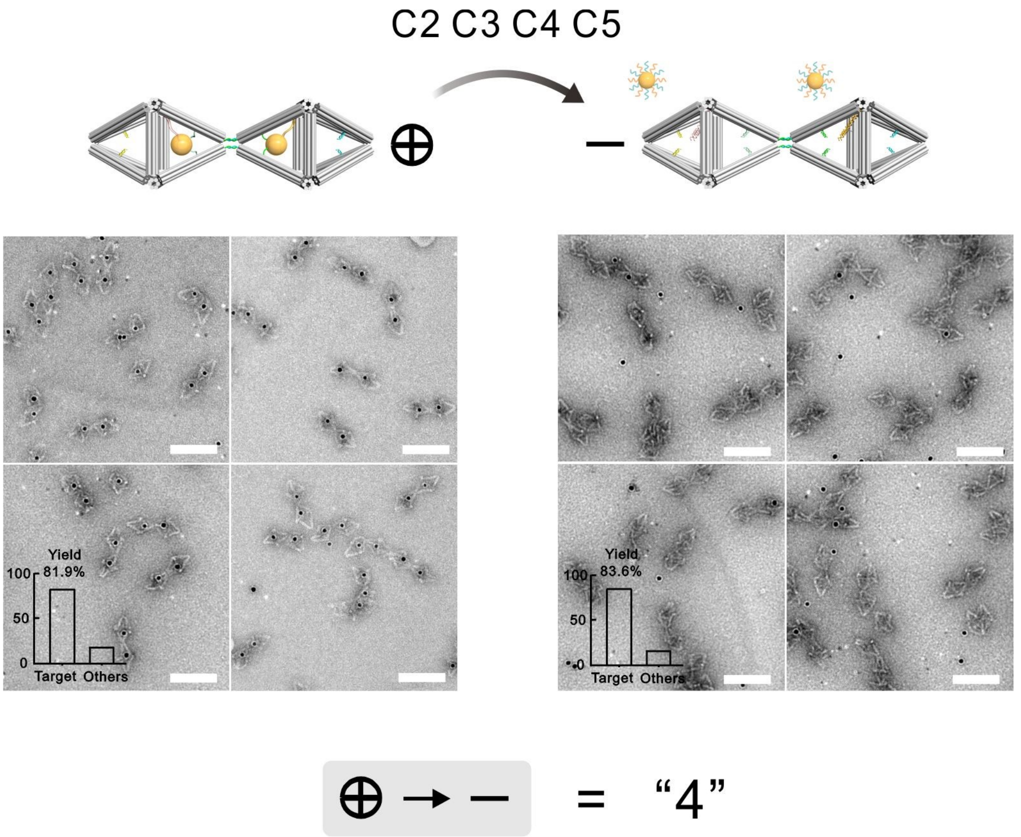

Fig. S37. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⊕→− " activated by information strands "C2 C3 C4 C5" for exporting the Arabic numeral "4". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

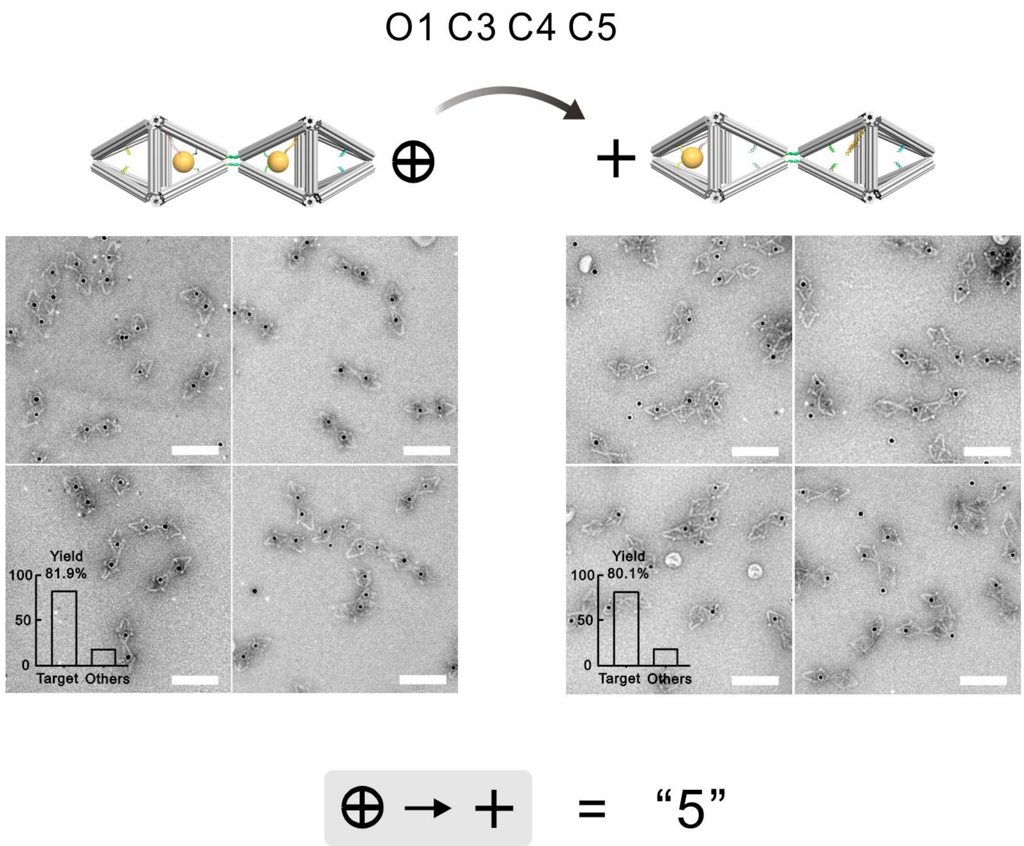

Fig. S38. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “⊕→+ ” activated by information strands “O1 C3 C4 C5” for exporting the Arabic numeral “5”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

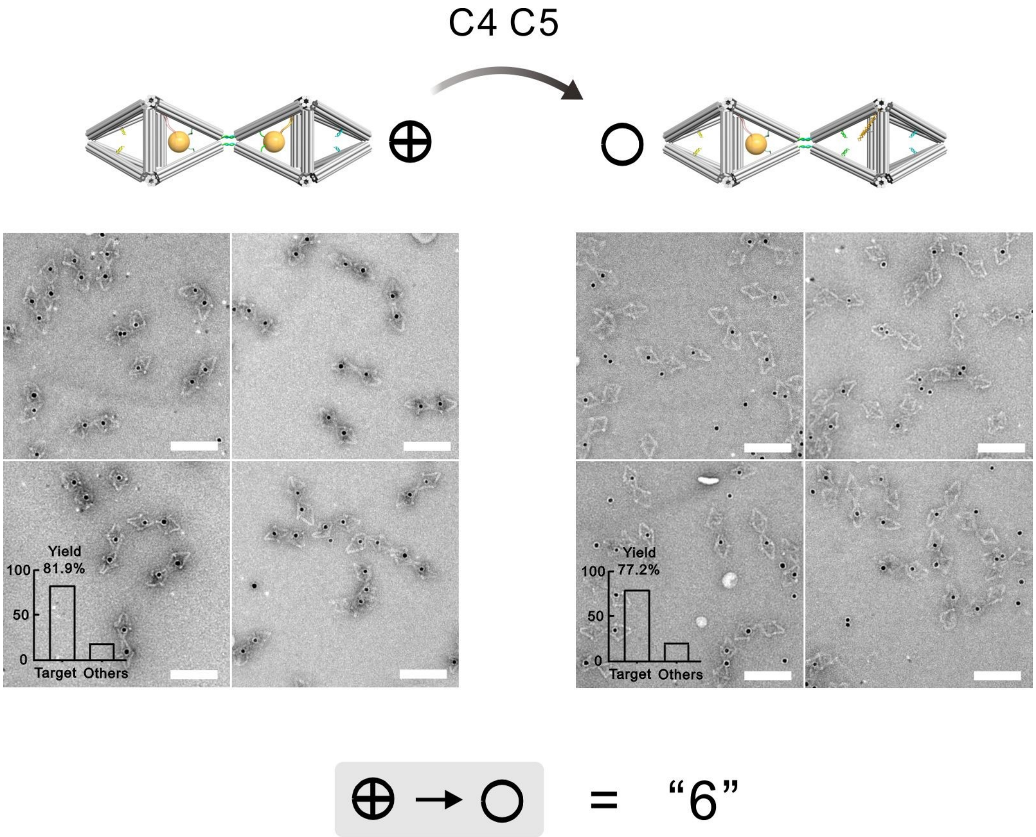

Fig. S39. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition “⊕→○ ” activated by information strands “C4 C5” for exporting the Arabic numeral “6”. Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. “Target” and “Others” respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

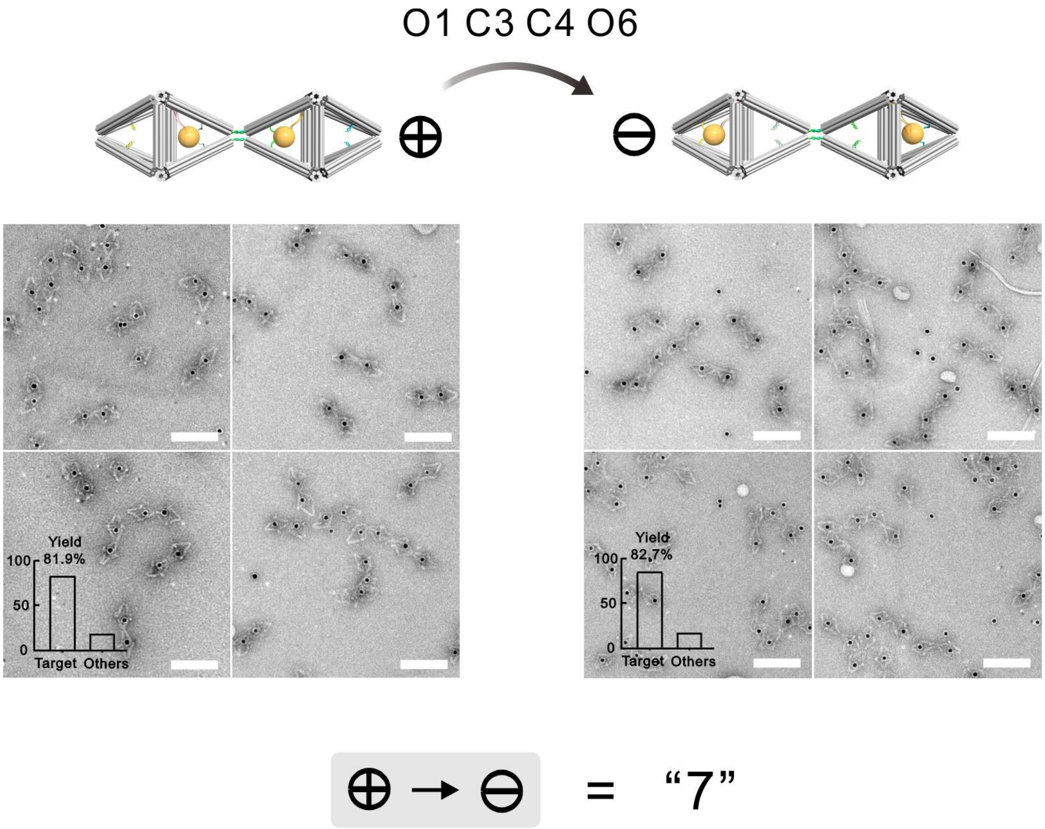

Fig. S40. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⊕→⊖" activated by information strands "O1 C3 C4 O6" for exporting the Arabic numeral "7". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

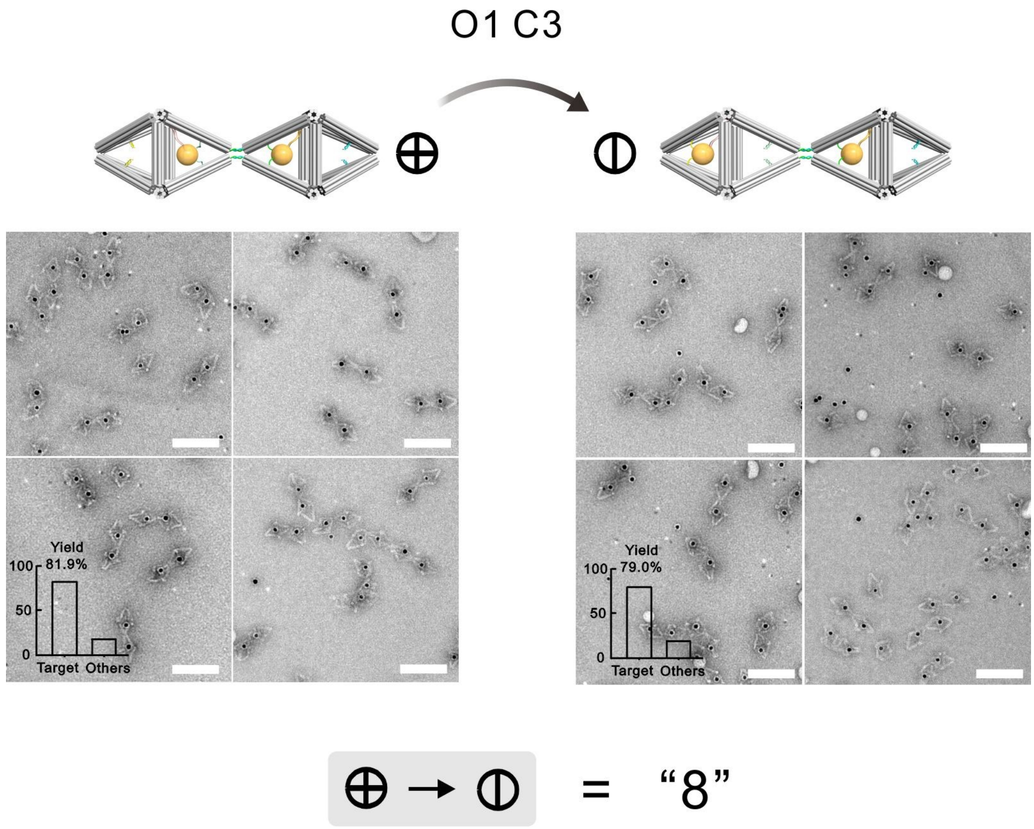

Fig. S41. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⊕→⦶ " activated by information strands "O1 C3" for exporting the Arabic numeral "8". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

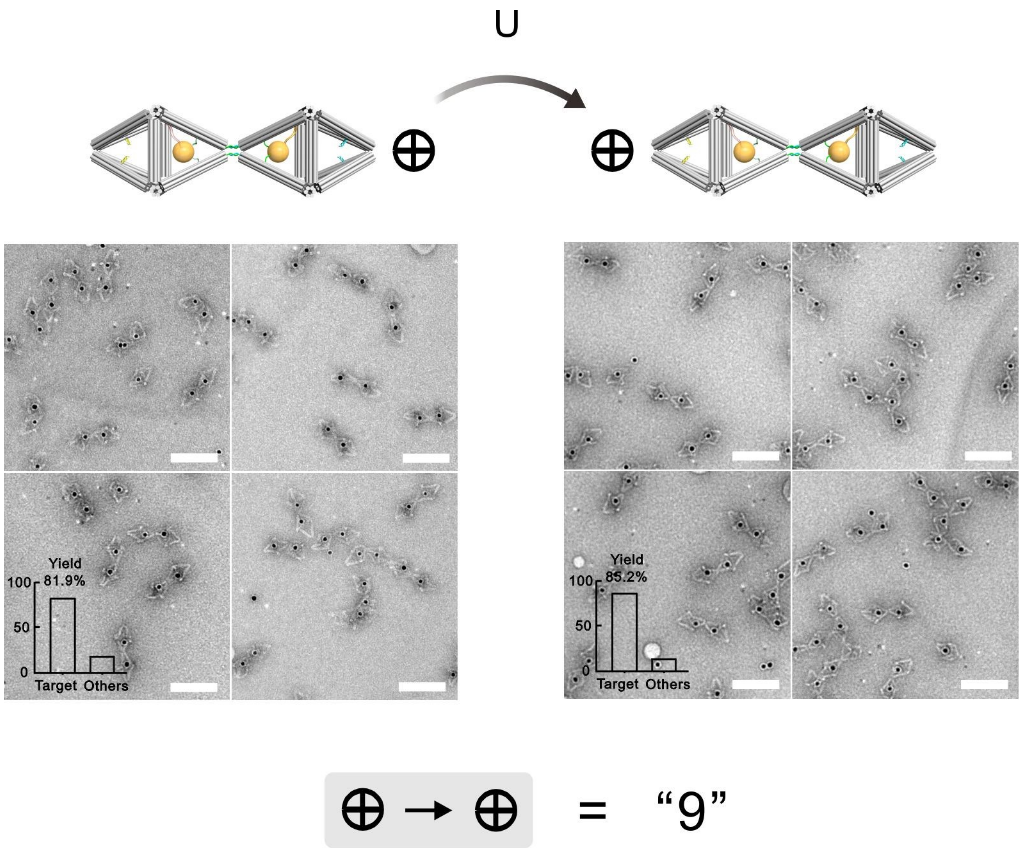

Fig. S42. Schematic and corresponding representative negative-stained TEM images of the DOCD undergoing the transition "⊕→⊕" activated by information strand "U" for exporting the Arabic numeral "9". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm.

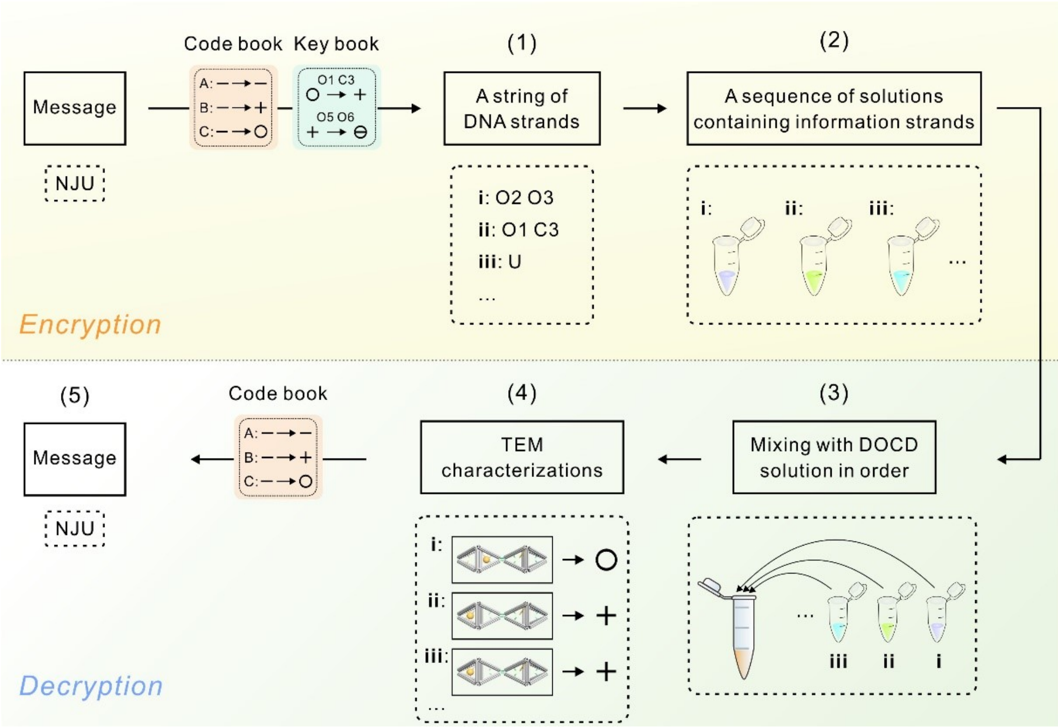

Fig. S43. A simple flow chart to explain the step-by-step cryptographic design pathway.

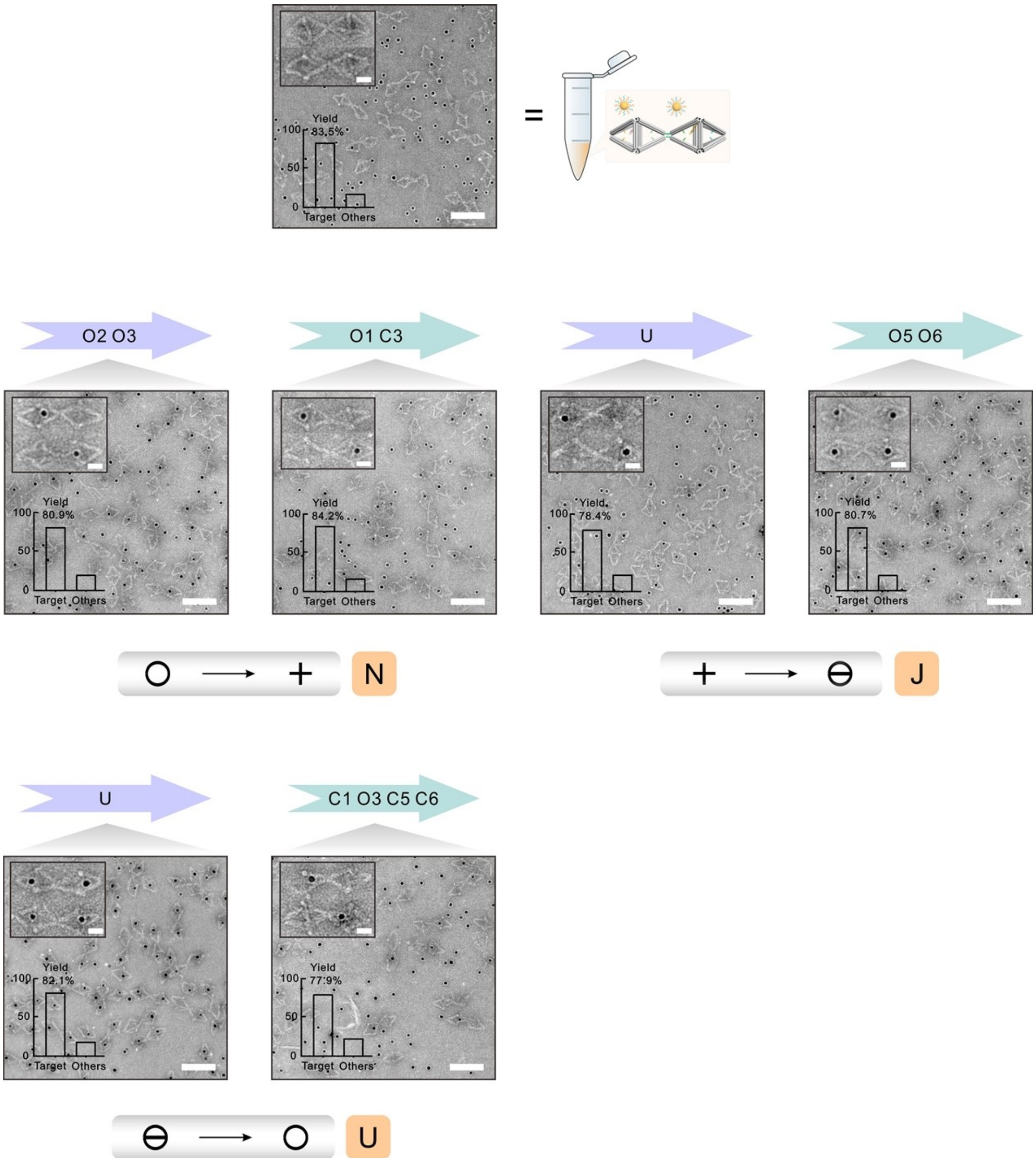

Fig. S44. The representative negative-stained TEM images of pattern transformation in the decryption process of example message "NJU". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm (inset: 20 nm).

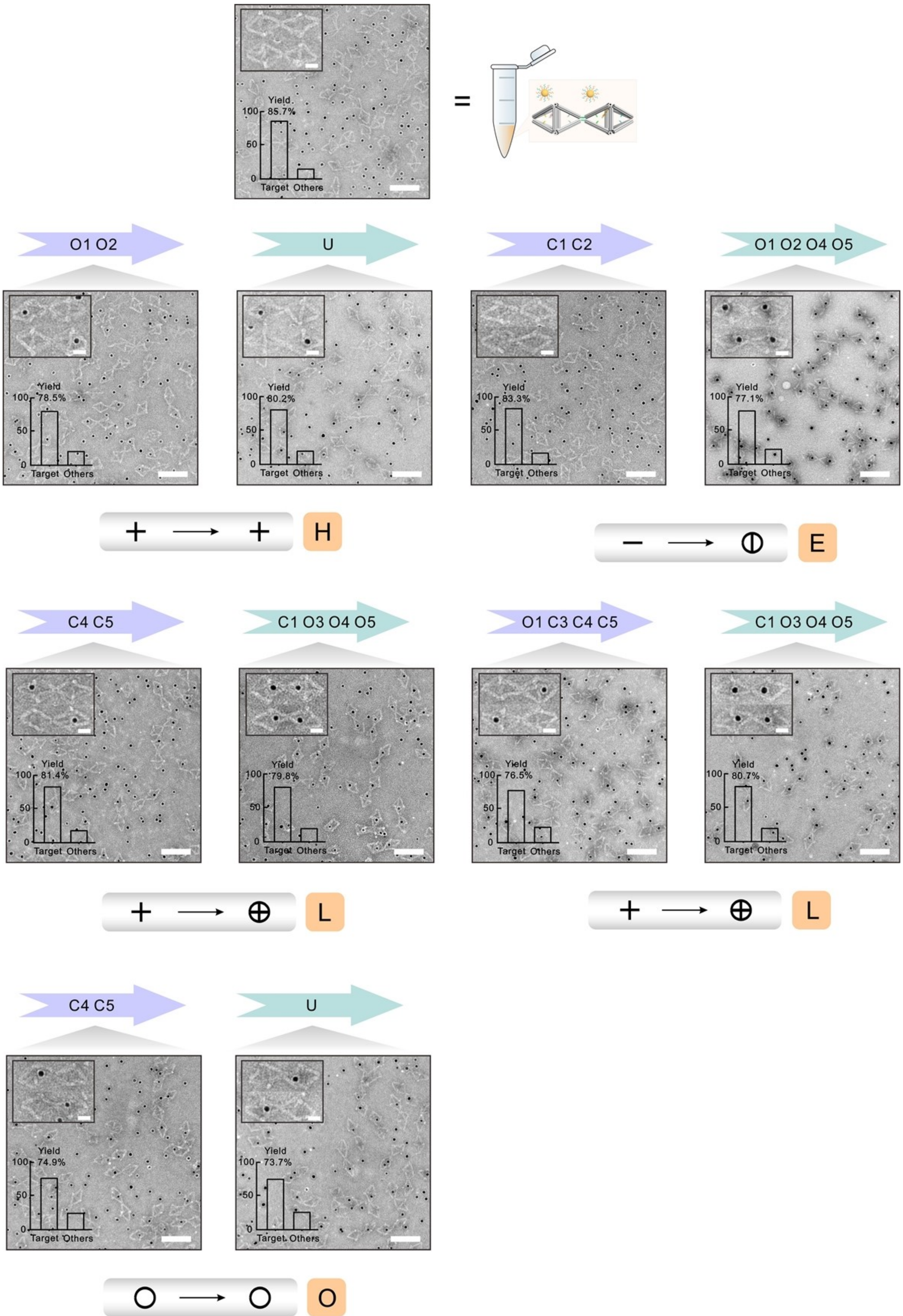

Fig. S45. The representative negative-stained TEM images of pattern transformation in the decryption process of example message "HELLO". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm (inset: 20 nm).

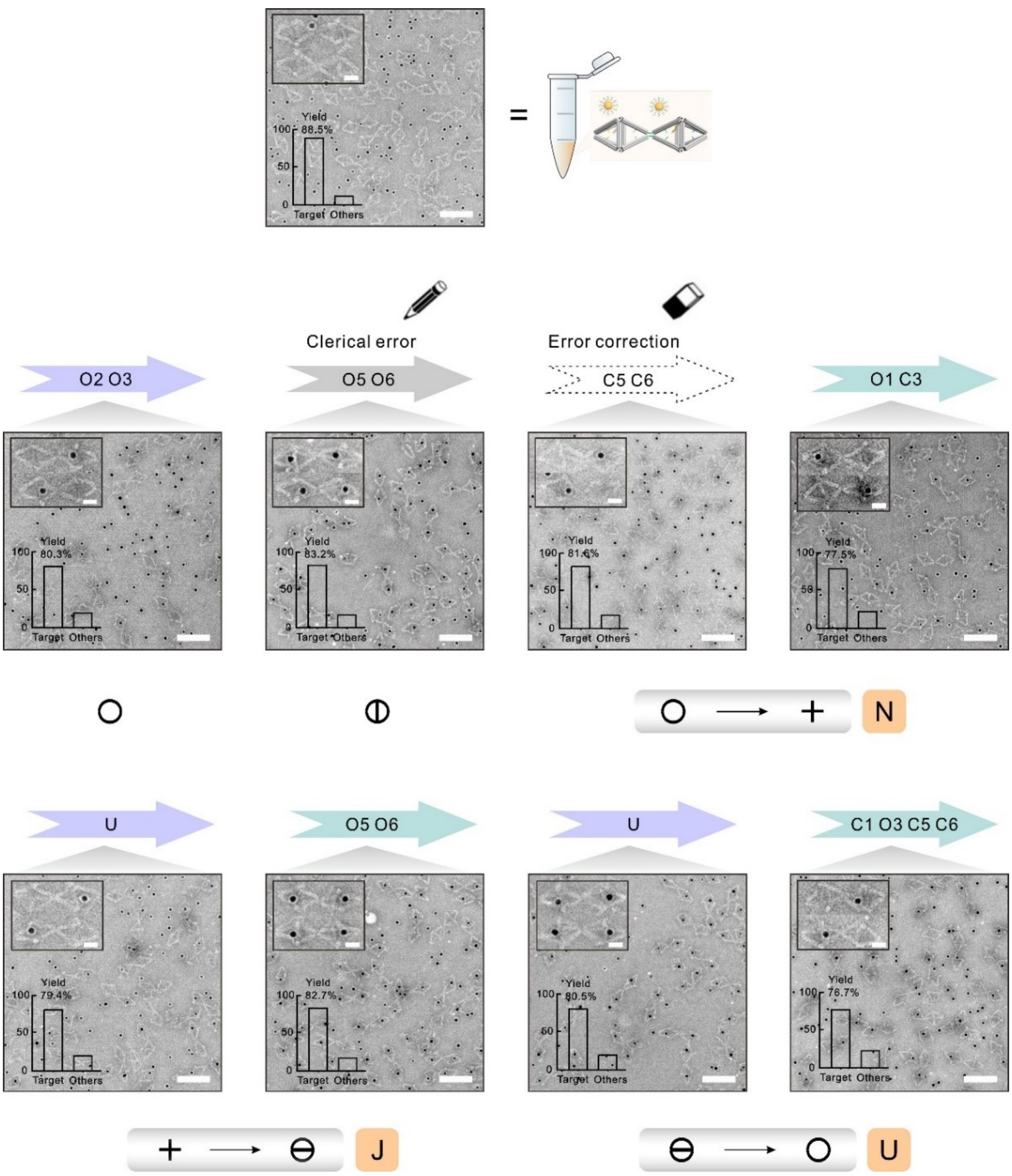

Fig. S46. The representative negative-stained TEM images showing error correction in the second step[a] during the decryption process of message "NJU". Insets show the population histograms for the prescribed target AuNPs-carrying Eoct-DOFs. "Target" and "Others" respectively represent the Eoct-DOF dimer structure consistent and inconsistent with the prescribed model. Scale bar: 100 nm (inset: 20 nm).

[a] In case that the decoder mistook "O5 O6" for the right information strands "O1 C3" in the second step and suddenly realized it, he/she could deduce the wrong strands causing the mistake by observing the resulting TEM images and referring to the key book. The eraser strands were then determined to be "C5 C6", which could be used to

turn the DOCD back to the previous cipher. Thereafter, the remaining five groups of information strands were successively decrypted by the DOCD from the breakpoint and eventually translated to be the message “NJU”.

Table S1. The efficiency statistics from one cipher symbol to another. The yields are obtained by counting the correct patterns from ~150 Eoct-DOF dimers as statistic sample in the TEM images for each case.

Character	Transition	Initial pattern	Yield	Final pattern	Yield
A	−→−		86.7%		88.5%
B	−→+		86.7%		84.2%
C	−→○		86.7%		89.9%
D	−→⊖		86.7%		83.2%
E	−→⦶		86.7%		80.4%
F	−→⊕		86.7%		85.4%
G	+→−		82.4%		88.3%
H	+→+		82.4%		79.8%
I	+→○		82.4%		82.7%
J	+→⊖		82.4%		84.4%
K	+→⦶		82.4%		81.9%
L	+→⊕		82.4%		81.6%
M	○→−		80.4%		88.3%
N	○→+		80.4%		79.6%
O	○→○		80.4%		83.2%
P	○→⊖		80.4%		84.4%
Q	○→⦶		80.4%		82.5%
R	○→⊕		80.4%		83.7%
S	⊖→−		84.1%		90.2%
T	⊖→+		84.1%		81.0%
U	⊖→○		84.1%		87.2%
V	⊖→⊖		84.1%		84.9%
W	⊖→⦶		84.1%		88.2%
X	⊖→⊕		84.1%		80.5%
Y	⦶→−		80.5%		82.2%
Z	⦶→+		80.5%		78.8%
0	⦶→○		80.5%		83.4%
1	⦶→⊖		80.5%		81.7%
2	⦶→⦶		80.5%		78.6%
3	⦶→⊕		80.5%		79.7%
4	⊕→−		81.9%		83.6%
5	⊕→+		81.9%		80.1%
6	⊕→○		81.9%		77.2%
7	⊕→⊖		81.9%		82.7%
8	⊕→⦶		81.9%		79.0%
9	⊕→⊕		81.9%		85.2%

Table S2. The volume change of the sample in each step during fluorescence measurements.

	Initial sample[a]	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Information strands		O2 O3 (0.6 μL 10 μM for each strand)	O1 C3 (0.9 μL 10 μM for each strand)	U (1.35 μL 10 μM)	O5 O6 (2.0 μL 10 μM for each strand)	U (3.0 μL 10 μM)	C1 O3 C5 C6 (0.45 μL 100 μM for each strand)
Total volume	212.4 μL	213.6 μL	215.4 μL	216.75 μL	220.75 μL	223.75 μL	225.55 μL

[a] The initial sample contained Eoct-DOF dimer (200 μL 5 nM), AuNPs (10 μL 200 nM) and closing strands 1-6 (0.4 μL 10 μM for each strand).

Table S3. Sequences of thiolated DNA strands modified on AuNPs.

Sequence name	Thiolated DNA sequence (5'-3')
HS-DNA 1	GAAGTGATGGATGAT-SH
HS-DNA 2	TAGGTGAGAAGTGAT-SH

Table S4. Sequences of anchor strands (Capture 66/86, Capture 138/125, Capture 97/98 for Eoct-DOF A; Capture 66'/86', Capture 138'/125', Capture 97'/98' for Eoct-DOF B).

	Sequence name	Staple sequence (5'-3')
Anchor 1	Capture 66	ATCCATCACTTCACTACACTATTTCGAGGAAAA CGTCAAAAATGAAAATAGCTACAGAGCTAAAGA
	Capture 86	ATCCATCACTTCACTACACTATTTCAGTTCAGA GAAGGATTAGTTTCGTCACTCAACTAATAACGC
Anchor 2	Capture 138	ATCCATCACTTCATACTCTACGTTGTTGTTGTT GTTGTTAGCCTAAAGCAAGCAAGAACGCGAG GCGTGAAGCCGCTACAATTTTATCCTGAA
	Capture	ATCCATCACTTCATACTCTACGTTGTTGTTGTT GTTGTTTCGTAAATAAAAATAGATTCAAAAGG

	125	GTATATGATGAGATCTACAAAGGCTATC
Anchor-3	Capture 97	ACTTCTCACCTATCATCTTACTTTGCTGAGATA TGGTTGCTTTAGTAGAAGAGGCGAATAATTACC
	Capture 98	ACTTCTCACCTATCATCTTACTTTAGTTTGAAA GCAAATATTTAAATTGTAAAGCCAGCAAATCTA
Anchor 4	Capture 66'	ATCCATCACTTCTACATCTCATTTCGAGGAAA ACGTCAAAAATGAAAATAGCTACAGAGCTAAAG A
	Capture 86'	ATCCATCACTTCTACATCTCATTTCAGTTCAGA GAAGGATTAGTTTCGTCACTCAACTAATAACGC
Anchor 5	Capture 138'	ATCCATCACTTCCACTTTCTCGTTGTTGTTGTT GTTGTTAGCCTAAAGCAAGCAAGAACGCGAG GCGTGAAGCCGCTACAATTTTATCCTGAA
	Capture 125'	ATCCATCACTTCCACTTTCTCGTTGTTGTTGTT GTTGTTTCGTAAATAAAAATAGATTCAAAAGG GTATATGATGAGATCTACAAAGGCTATC
Anchor 6	Capture 97'	ACTTCTCACCTACACTAATCATTTGCTGAGATA TGGTTGCTTTAGTAGAAGAGGCGAATAATTACC
	Capture 98'	ACTTCTCACCTACACTAATCATTTAGTTTGAAA GCAAATATTTAAATTGTAAAGCCAGCAAATCTA

Table S5. Sequences of sticky end strands and closing end strands (sequence 1-4 for Eoct-DOF A; sequence 1'-4' for Eoct-DOF B).

Sequence name	Staple sequence (5'-3')
Sticky end 1	CAATAGATAATATAAATCCTTTGCCCGG CGGTCTCAATCAATTAACCTAACCTTCAT
Sticky end 2	TTTAATGCGCGAAAGATAAAACAGAGCC AGCCAACCAGTAATTAACCTAACCTTCAT
Sticky end 3	TAACCGTTGTAGTCCAGAACAATATTTCG CCTGAACAAAATTTAACCTAACCTTCAT
Sticky end 4	GAAATTGCGTAGGGAGAAACAATAACGT TATTAGCAATTCATTAACCTAACCTTCAT
Sticky end 1'	AAAGTACAACGGGTTACTTAGCCGGACT CAGCAATACGTAATATGAAGGTTAGGTTA
Sticky end 2'	ATAGTTGCGCCGTTTTGCGGGATCGTGTT AGCGAGGAATTGCATGAAGGTTAGGTTA
Sticky end 3'	GTGAATTACCTTAACGGAACAACATTGGC GCAGGATATTCATATGAAGGTTAGGTTA
Sticky end 4'	TTTTCAGGGATACCACAGACAGCCCTCAG GTAGATCATAACCATGAAGGTTAGGTTA

Closing end 1	AAAGTACAACGGGTTACTTAGCCGGACTC AGCAATACGTAATTTTTTTTTTTTTTTT
Closing end 2	ATAGTTGCGCCGTTTTGCGGGATCGTGTTA GCGAGGAATTGCTTTTTTTTTTTTTTT
Closing end 3	GTGAATTACCTTAACGGAACAACATTGGC GCAGGATATTCATTTTTTTTTTTTTTTT
Closing end 4	TTTTCAGGGATACCACAGACAGCCCTCAGG TAGATCATAACCTTTTTTTTTTTTTTT
Closing end 1'	CAATAGATAATATAAATCCTTTGCCCGGCG GTCTCAATCAATTTTTTTTTTTTTTTT
Closing end 2'	TTTAATGCGCGAAAGATAAAACAGAGCCA GCCAACCAGTAATTTTTTTTTTTTTTTT
Closing end 3'	TAACCGTTGTAGTCCAGAACAATATTTCGC CTGAACAAAATTTTTTTTTTTTTTTT
Closing end 4'	GAAATTGCGTAGGGAGAAACAATAACGTT ATTAGCAATTCATTTTTTTTTTTTTTTT

Table S6. Sequences of information strands.

Sequence name	Staple sequence (5'-3')
Closing strand 1	ACACATCTTAGTGTAGTGAAGTGA
Closing strand 2	TTACATCAGTAGAGTATGAAGTGA
Closing strand 3	ACTCACTTGTAAGATGATAGGTGA
Closing strand 4	TCACTTCTACATCTCAGTAGTTGA
Closing strand 5	TTCTACTTGAGAAAGTGGAAGTGA
Closing strand 6	TCTCACTTTGATTAGTGTAGGTGA
Opening strand 1	TCACTTCACTACACTAAGATGTGT
Opening strand 2	TCACTTCATACTCTACTGATGTAA
Opening strand 3	TCACCTATCATCTTACAAGTGAGT
Opening strand 4	TCACTTCTACATCTCAGTAGTTGA
Opening strand 5	TCACTTCCACTTTCTCAAGTAGAA
Opening strand 6	TCACCTACACTAATCAAAGTGAGA
Poly T	TTTTTTTTTTTTTTT

Table S7. Sequences of fluorophore-modified capture strands.

Sequence name	Staple sequence (5'-3')
Capture-66-FAM	FAM-ATCCATCACTTCACTACACTATTCGAGGAAAA

	CGTCAAAAATGAAAATAGCTACAGAGCTAAAGA
Capture-98-Cy3	Cy3- ACTTCTCACCTATCATCTTACTTTAGTTTGAAA GCAAATATTTAAATTGTAAAGCCAGCAAATCTA
Capture-66'-ROX	ROX- ATCCATCACTTCTACATCTCATTTCGAGGAAA ACGTCAAAAATGAAAATAGCTACAGAGCTAAAG A
Capture-98'-Cy5	Cy5- ACTTCTCACCTACACTAATCATTTAGTTTGAAA GCAAATATTTAAATTGTAAAGCCAGCAAATCTA

Table S8. Sequences of staple strands of Eoct-DOF.

Sequence name	Staple sequence (5'-3')
Eoct 1	CTCGTTTACCAGACGACAACACTAAAGATT
Eoct 2	AAAAGGGACATTCTGGTCACACGTTGCAAC
Eoct 3	GCCACTACGAAGGCACGGGTAAAGCGAAAG
Eoct 4	TTGGGGCGCGAGCTGATTAGCTATTCCATA
Eoct 5	TTCAAATATATTTTAGAACGCGACCTCCGG
Eoct 6	CAATATAATCCTGATTGATGATGATTTTAA
Eoct 7	CAGACTGTAGCGCGTTAGTTTGCCCAGTAG
Eoct 8	GTCCACTATTAAAGAACCAGTTTTGGTTCC
Eoct 9	GAATAATAATTTTTTCCAACTAATAACGAT
Eoct 10	GGCCGATTAAAGGGATCGGGAGCCCGCCGC
Eoct 11	GCCTCTTCGCTATTACAGGGCGAGCACCGC
Eoct 12	AAGCCAGAATGGAAAGAAATAAACAGAGCC
Eoct 13	CCAGACGACGACAATAGGTAAAGCTCAACA
Eoct 14	TACCCAAATCAACGTAAGAACCGACGGTCA
Eoct 15	TTGCGCTCACTGCCCGACTCACACATGGTC
Eoct 16	AATTACATTTAACAATTCAAGAAATTGCTT
Eoct 17	GCCATCAAAAATAATTTTTAACCTAATCAG
Eoct 18	AGTCAAATCACCATCAGAGAAAGTTTCAAC
Eoct 10	AACAAAGTCAGAGGGTTTAACTGTTATCCC

Eoct 20	TTATTTTGTCACAATCACACCACACGCAGT
Eoct 21	ATCTGGTCAGTTGGCACAAACCCAGTATTA
Eoct 22	TAAGTATAGCCCGGAAGTCGAGAAAACATG
Eoct 23	AGCGAACCAGACCGGATTAATTCGTCAGAA
Eoct 24	GACTTGCGGGAGGTTTTTTAGCTTACCGC
Eoct 25	ACAGCATGCTCCATAGATTTGTATCATCCC CAGCGAAACGAA
Eoct 26	GAAATCGGCCCCCTACGGGGTCAGTGCCCT TTTGATCCAACG
Eoct 27	AACGGGTCCTGAACAAGAAAAATAATATCT TATCATTCCAAG
Eoct 28	AAAAGCCCTCAGGACGTTGGTGTAGATGGG GAACAGGCCTTC
Eoct 29	ATTAAATCAGCTTTCATCAACATTAAATTTG TTAAAATTCGC
Eoct 30	TACATTTAATAGTACATCCAATAAATCAAA GCTAACCAAAAA
Eoct 31	GCCCAATTTTGCCATAACGAGCGTCTTTGCA CCCATTAAATC
Eoct 32	ATAGCGAAATTACGTAGGAATACCACATCA GTACAGTACCGT
Eoct 33	GTTGGGATGAAAGAGGACAGATGAACGGAG TAGATCATTAGA
Eoct 34	CTTTTTCAAAGAATACTCATCTTTGACCGCCT GATGAAATCC
Eoct 35	AAGCCTGCGTGCCAGCTGCATTAATGAAAAG CATAAAGTGTA
Eoct 36	TCAGTGATCATCAAGAACTGACCAACTTAGAA AAATCTACGT
Eoct 37	TAACAGTACCCTGTAGCCTCAGAGCATATACA GGCGCATCAA
Eoct 38	CTAATGCGAATATAAGAATCGCCATATTTACC GCACTCATCG
Eoct 39	ATAGCTGTTGCCCCCGGGCAACAGCTGAATTG GGCGTCGGGA
Eoct 40	GCCGCCATGTAGCGGGAAGGGAAGAAAGAGA GCTTTCTGAAT
Eoct 41	GGAATTAAATGGAACTACCATATCAAAACGTC AGAGTAACAG
Eoct 42	TCTGAATTCATCATTTATCATTTTGCGGTAATA CATGAATGG

Eoct 43	AGAGGCAATGAGGAAGGGTAGCAACGGCAGG TGTCAAATTCC
Eoct 44	CGTTCTATAGGTAATTTTAGAACCCTCAAGGA TGAACGGTAA
Eoct 45	TTCTACTCGCAAATCAATTCTGCGAACGTGTT GTAATCGGTA
Eoct 46	AGGAAAACCAGCAGACTGATAGCCCTAAACA ATATAGATAGA
Eoct 47	GAGCCGGTCGTAAGAAAGCGGCCAACGCTGA TCGTGCTCAAG
Eoct 48	AAACAGGAGATAACCCACAAGAATTGAGAGA GAATAACATAA
Eoct 49	GTGCATCACAACCCGTCGGATTCTCCGTGGCG CATCGTAACC
Eoct 50	CTAAAGTAGGCCGCACAATGACAACAACTGA ATTTAAATCTC
Eoct 51	AATCCAACAAAAGAAAGTAAGCAGATAGAA TAGCACGCTAAT
Eoct 52	TAACGTGAGAATCCGTGAGTGAATAACCACA TAGCGATAGCT
Eoct 53	GGATTATTGACCTGAATACGTGGCACAGAAC ATCGTACCGAA
Eoct 54	GTACGCCCTTTCCTTACAGGGCGCGTACAGAG TCAATAGTGA
Eoct 55	ATCATTTCGAAAGGAGCGGGAATAGCCCGCG AAAAAGCGTCA
Eoct 56	TTAATTGATATAATGCTGTGGAAGCCCGATTA GAGAAGGCGA
Eoct 57	ATCATAAACGAACTATGCGATTTTAAGAATGG TTTTGCTCAT
Eoct 58	AAGCATCGAGGAAGATATCTTTAGGAGCGAAG TATAAACAAT
Eoct 59	AAAGTATTCAAAAAGTCATAAATATTCAAAAT GTTATCACCG
Eoct 60	GCAAGGAACTAGCAGAGAGTCTGGAGCATTTT TGAATTCAAC
Eoct 61	ATCAGAGGAAGCGCACGATTTTTTGTTTACGCA ATAATAACG
Eoct 62	CACCATTACCACCCGCCTCCCTCAGAGCTAATC AAGCATTTT
Eoct 63	TTTGCTAAAAGCGTTTATTTTGTATCGGATACC ATATGAAAT
Eoct 64	TAATGTGGCTGATAAATTATGCTATTTTCCGCA ATGCCTGAG

Eoct 65	TAGATTAAATATATTGAGAAGTGTTTTTTGGA CGAGCACGTA
Eoct 66	CGAGGAAAACGTCAAAAATGAAAATAGCTAC AGAGCTAAAGA
Eoct 67	ATGTTAGTTATACACCGGAATCATAATTGACC GTGAATTCAT
Eoct 68	CAAAAGGGAGGCTTGCCACCCTCAGAACAAC CCATAACTACA
Eoct 69	AAGATTAGTATTCTAAATCAGATATAGATATA TTTTAAATAG
Eoct 70	AACCGATTTTATCAGCTTGCTTTCGAGGCATCG CCCACGCAT
Eoct 71	CAAAAAACGGAGTGTCTTTCCAGACGTTCTGA GGCTTGCAGG
Eoct 72	TCGGTCGAGTAAATGAATTTTCTGTATGGTCA CCACGATAGC
Eoct 73	CAGACCAAAATTAAGTAGCCACCAGAACGGT TGACTTAGTAC
Eoct 74	CAGAGGCAAAGAACGGGTTTAGATAAGTATA CCAGAAACCTA
Eoct 75	GTTTCAGAAGGCTCCAAAAGGAGCCTTTAACA ACTTTCAACA
Eoct 76	AACCTGTGGGTGCCTGTGAAATTGTTATCAGC AAGCGGTCCA
Eoct 77	CAGAAGGAATAAGAGCAAGAAACAATGACCG AACAAAGTTAC
Eoct 78	TTTACAGTTAAAACACACTAAGCCCAATAAGA GGAGCTTTAC
Eoct 79	GTAGGGCGCAAGCCATCGGCTGTCTTTCCCCA TCCTGTTCAG
Eoct 80	AAGTTTGTACATCGATTTTCAGGTTTAATTATT TGTTATACT
Eoct 81	ACTTGCCATAATCAACAGTACATAAATCAGAT TTCTATTCAC
Eoct 82	TAATATTGTCTAAAGTTATGAGCGAGTATGAT GAAAGCAACC
Eoct 83	ATGGTTTACATATAAGAAAATACATACAAACT GTTTAGTATC
Eoct 84	CGGTCATTAATCAGGCAAGGCCGGAAACGGA ACCGCTCAGAT
Eoct 85	ACCCTTCTTACATTTGGAAATACCTACAATAAA AACCATTAC
Eoct 86	CAGTTCAGAGAAGGATTAGTTTCGTCACTCA ACTAATAACGC

Eoct 87	GGTCAGGAAAGACTATCAAAAAGATTAACAC CTGCAGGTCGA
Eoct 88	TGAGCAAAATGGAAGTGAGGCCACCGAGTTA GTAACTATCGG
Eoct 89	AGAGTTGCCGCTCACAATTCCACACAACTTTT GACCTGAAAT
Eoct 90	AGCACCGAGCCCCCTTGCCATCTTTTCACGCC ACCCCACCCT
Eoct 91	CTTTTTTAAGAAGACAAAATCGCGCAGAACTC AAATAACATC
Eoct 92	AGGAATTACCTTGCAGTGCCACGCTGAGACTT TACTAGACGT
Eoct 93	CCAGTCAGAGTAGTAAATTGGGCTTGAGACTG GCTCATTATA
Eoct 94	GCAAAGCGGATCCCACGACGGCCAGTGCGGGT AACTCCAACA
Eoct 95	AACACTGCAGAACCTTGCAAAAGAAGTTTAGA TACATGCAAA
Eoct 96	CCACCCTAGGATTAGCGGGGTTTTGCTCGAGGT TTAGGGGGT
Eoct 97	GCTGAGATATGGTTGCTTTAGTAGAAGAGGCG AATAATTACC
Eoct 98	AGTTTGAAAGCAAATATTTAAATTGTAAAGCC AGCAAATCTA
Eoct 99	GCTTAATAAAATCATAGAATCCTTGAAATTGC TTCAGGAACG
Eoct 100	TCAAAGGGAGATAGCCCTTATAAATCAAAGG CCCGTATAAAC
Eoct 101	TTCTGGTATGCAACAGCTTAATTGCTGACTCC TTTGGCGAAA
Eoct 102	AATAAGAAGAACGCGCCTGTTTATCAACATTT TCGAGCCAGT
Eoct 103	CTTAGGTGAGCCATGACGGAAATTATTCGCGA CATCATCTTC
Eoct 104	AAATACCACTAGAAAAAGCTGCTGATGCAATT TAACCAAAGA
Eoct 105	TGAATACGGTAATACAATACTTCTTTGATAAAA GAGAATTAC
Eoct 106	TGACCTAAAATCCATATAACTATATGTATATTA TCACCGTCA
Eoct 107	CTGTAGCTTTTGTTCAGGAAGATTGTATGGGGA CGACGACAG
Eoct 108	GGGGGATCAGGCTGACCAGGCAAAGCGCGAAG CTCAACATGT

Eoct 109	ACACCGCCTCGTATCATTTGAGGATTTAACTAA CAAGTTGAA
Eoct 110	CTGGCCCGCGGGGAGAGGCGGTTTGCGTTTGCC CTTCACCGC
Eoct 111	TACTCAGAGTACCACTGAGACTCCTCAAGAAAA CGAGAATGA
Eoct 112	AATAGTATTGAATCCCCCTCAAATGCTTTTGCCA GAGTACCG
Eoct 113	CAAAAGGATTAAAGGTGAAAAGGTGGCAACCA GCGTGGTTTG
Eoct 114	TTACCGTTTGGCCTCAGGAGGTTGAGGCAAGC GCTAGGGCGC
Eoct 115	TACATGGTTGAGTAACAGTGTCAGACGATCCA GTAACCGTCT
Eoct 116	TTAAGTTCAAGCTTGCATGTTCGCCATTGTGCT GCAGTACCT
Eoct 117	TTATCCGGTATGCCGGAGAGGGTAGCTAAACA AGAGAATCGC
Eoct 118	CTGACCTATAAGGCTTGCCCTGACGAGAGGCG CATAGGCTGG
Eoct 119	AACCAAGTAACAACGCCAACATGTAATTAACA AAGAAGGAGC
Eoct 120	CATCAGTTAGCATTGCAAGCCCAATAGGCGCC ACCAACCAAA
Eoct 121	AGTTAATGCAAAATGGTTGAGTGTTGTTCGTG GACTGATACAGGAGTGTACTGG
Eoct 122	GAATACCATAAGAAATTAGACGGGAGAAAAT TGAGATAGCTATCTTACCGAAGC
Eoct 123	GCGACCTCGGAACGAGTTTCCATTAAACCAAC CTAATTATACCAAGCGCGAAAC
Eoct 124	TATCGGCCCAAAAAAAATCAGCTCATTTCGCG TCTAACGGCGGATTGACCGTAA
Eoct 125	TCGTAAATAAAAATAGATTCAAAAGGGTATAT GATGAGATCTACAAAGGCTATC
Eoct 126	CATTATGTGATTCCGGTCAATAACCTGTAAAG GTGAAGGCAAAGAATTAGCAAA
Eoct 127	AGAACAATTAATTGAAGTACCGACAAAAAAC AACATAATTTACGAGCATGTAGA
Eoct 128	ATATGCGCAAACGTAAAGAAACGCAAAGAA TAGAATGATAAATAAGGCGTTAAA
Eoct 129	CCGACTTTGGGTTAATCGCAAGACAAAGTTA ATTTTCAACCGATTGAGGGAGGG
Eoct 130	ACGCCTGTGAGATTAGGCATAGTAAGAGCGA TAAACTCAGAGCCACCACCCTCA

Eoct 131	CGCTGGTTTTCCTGTAATGAGTGAGCTACTTT CCAGCCAGGGTGGTTTTTCTTT
Eoct 132	CGAACCAACGCTCAGGCAGATTCACCAGCCA ACAGTTTTGAATGGCTATTAGTC
Eoct 133	TAATAAAGGGAACCGAGTAATCTTGACAACA AAGCAATTTCAACTTTAATCATT
Eoct 134	CCTTGCTCAAGTTATGATGAAACAAACATTCA TTTGTCTGTCCATCACGCAAAT
Eoct 135	GAGTTAATTTGTCGAGAATAGAAAGGAAACG TTGACTTAAACAGCTTGATACCG
Eoct 136	TGGCAAGGCATTGATGATATTCACAAACCGCA GTCGACGGGGAAAGCCGGCGAA
Eoct 137	TCGACAACTGCAACTGAACCTCAAATATAATC AACACTAATAGATTAGAGCCGT
Eoct 138	AGCCTAAAGCAAGCAAGAACGCGAGGCGTGA AGCCGCTACAATTTTATCCTGAA
Eoct 139	CAGAGCCACCATTATAGCGACAGAATCATTCA TCGAATCACCGGAACCAGAGCC
Eoct 140	TACCTTTAGTAACAATTCCTGATTATCAGTTTG GACACGTAAAACAGAAATAAA
Eoct 141	CTCTAGAGGATTGCTCAAATATCGCGTTAGCAA ACGCCAGGGTTTTCCCAGTCA
Eoct 142	TTTAAATGCCGGAACGCAACTGTTGGGAGCCA GCTTGATAAGAGGTCATTTTTG
Eoct 143	ATTTATCGCGCCGCCGTTAGAATCAGAGTTTAG ACTGTAAATCGTCGCTATTAA
Eoct 144	CCATAAATAAGAGGGGCGGATAAGTGCCTAGG TGTTAGACTGGATAGCGTCCAA

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