

The biomimetic Cu(I) ethylene receptor: significance, competitive position, and implications for Ambient IoT.

An internal strategic assessment of the Cu₂Cyt sensing chemistry developed by Xu, Zhang et al. and the wider research line led by Prof. Junfeng Wu (Henan Agricultural University), and what it means for Ambient IoT's portfolio, AgroFresh deployment route, and the proposed Wu collaboration.

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Executive summary

Xu, Zhang et al.'s April 2026 Nature Communications paper — published from the research lab of Prof. Junfeng Wu at Henan Agricultural University — describes the first ethylene chemiresistor that operates at room temperature, contains no noble metals, achieves a sub-ppb detection limit, and uses a coordination chemistry directly modelled on the biological ethylene receptor. It is, in our assessment, the most significant single advance in selective ethylene sensing chemistry of the last decade.¹

The significance is not in the absolute numbers — although a 1.07 ppb detection limit at room temperature without platinum or palladium is genuinely remarkable. The significance is in the strategy. By copying the sulfur-bridged Cu(I) binding site that plants use natively to detect their own ripening hormone, Wu's group has provided a route to selectivity that no engineered chemistry has matched. Selectivity, not sensitivity, is the persistent barrier to commercial ethylene sensing in the presence of 1-MCP, mixed fruit VOCs, ethanol, ammonia, and humidity. That is the barrier this chemistry plausibly breaks.

For Ambient IoT, the implications are directional, not threatening. Wu's chemistry sits **upstream** of every Ambient IoT and Moseley patent. The Australian counter-portfolio — most notably AU 2026904494 (Metal-Cystine Sensor Array genus) and AU 2026904524 (E-MOF-Receptor genus, filed 11 May 2026) — was constructed specifically to claim the array architecture, the receptor-in-host integration, the ML fusion, the predictive trajectory inference, and the semiconductor AMC embodiments above any specific receptor chemistry. A successful collaboration with Wu's group is the cleanest path to a commercially viable cold-chain product. The

MNDA is the right next step.

BOTTOM LINE

Wu's chemistry is the receptor. Ambient IoT is the system that hosts, stabilises, multiplexes, predicts with, and deploys around that receptor. The two sides are complementary, not competing. The collaboration is worth pursuing on its scientific merit alone — and the integration IP we have already filed protects our commercial position regardless of whether the collaboration succeeds.

1 · What was published, and why it is novel

1.1 The chemistry

Plant cells detect the gaseous hormone ethylene using a family of membrane-bound receptors — ETR1 and four homologues in Arabidopsis. Since Rodríguez, Bleecker and colleagues showed in 1999 that a monovalent copper ion bound at a sulfur-containing site in the receptor is essential for ethylene binding, it has been understood that Cu(I), coordinated by cysteine sulfur and histidine nitrogen, is the chemical machinery nature uses to recognise C₂H₄ at sub-ppb levels with absolute selectivity.²³

Xu et al.'s contribution is to construct a synthetic small-molecule analogue of that biological site — a cuprous-cystine complex they call **Cu₂Cyt** — that preserves the sulfur-bridged Cu(I) coordination geometry but exists outside the protein scaffold. Cystine, the disulfide dimer of cysteine, provides the sulfur ligands. The complex is then composited with MXene (Ti₃C₂T_x) and deposited as a thin film on a flexible interdigital electrode. The MXene provides the electrical readout pathway; the Cu₂Cyt provides the selective recognition.¹

1.2 The performance

The headline performance numbers, taken from the paper, are summarised below alongside the closest published benchmark (Chen, Wei and Stanciu's 2020 Cu(I)-pincer / MoS₂ system from Purdue) and a typical commercial electrochemical sensor.

| Metric | Xu et al. Cu ₂ Cyt / MXene (2026) | Chen et al. Cu(I)-pincer/MoS ₂ (2020) | Commercial electrochemical |
|------------------------|--|--|-------------------------------------|
| Detection limit | 1.07 ppb | 100 ppb | ~50 ppb |
| Linear range | 0.05 – 5 ppm | sub-ppm | 0.1 – 200 ppm |
| Response time | 51 s | minutes | 30 – 120 s |
| Recovery time | 92 s | minutes | 60 – 300 s |
| Operating temp | Room temperature | Room temperature | Room temperature |
| Noble metals | None | None | Often Pt, Pd |
| Form factor | Flexible / wearable | Printed on plastic | Handheld / fixed |
| Selectivity strategy | Biomimetic Cu(I)-S coordination | Cu(I)-pincer as n-type dopant | Electrochemical at biased electrode |
| Demonstrated stability | Reversibility & reproducibility shown; long-term cold-chain data not published | 1 month in lab | 6 – 24 months in field |

Two numbers in this table matter more than the others. First, a **1.07 ppb detection limit** at room temperature is approximately two orders of magnitude better than the previous best biomimetic chemiresistor and one to two orders of magnitude better than the typical commercial electrochemical cell — enough sensitivity to detect the onset of climacteric ethylene production from a single piece of fruit metres away.⁴ Second, the architecture is **noble-metal-free**. Platinum,

palladium and ruthenium dominate the prior art and are the primary reason ethylene sensors do not yet sit inside reefer containers at single-pallet density. Removing them brings unit cost down by one to two orders of magnitude.

1.3 What is genuinely new — and what is not

Cu(I) coordination chemistry for ethylene sensing is not new in itself. Swager and others at MIT and Purdue have spent the last decade demonstrating that Cu(I) complexes — pincers, scorpionates, and various tridentate ligands — are the natural choice for selective C₂H₄ binding in synthetic sensors.⁴ What is new in Xu et al. is three things acting together:

- **The ligand choice.** Cystine is biological — cheap, abundant, water-soluble, and naturally available — and the dimerised sulfur-sulfur geometry it provides is closer to the biological binding site than any prior synthetic pincer.
- **The transduction partner.** MXene is conductive, hydrophilic, surface-functional, and accepts the Cu₂Cyt by simple solution deposition. The MXene-receptor charge transfer is what converts a molecular binding event into a measurable resistance change.
- **The fabrication economics.** Interdigital electrode on flexible substrate + drop-cast composite + no metallisation. This is genuinely a wearable-class fabrication cost, not a lab-only demonstration.

What is not new — and this matters for our IP positioning — is the underlying idea of a copper-cystine ethylene receptor mimic, the array concept, the ML fusion of heterogeneous sensor channels, the predictive trajectory inference, the receptor-in-porous-host integration approach, or any extension into semiconductor airborne molecular contamination. Those are layers above the chemistry, and they are where Ambient IoT's filings sit.

2 · The Wu research line and its trajectory

Prof. Junfeng Wu leads the photonics and laser-spectroscopy laboratory at Henan Agricultural University (Zhengzhou, China).⁵ The Henan group has been publishing steadily on plant phytohormone sensing — salicylic acid, indole-3-acetic acid, and now ethylene — using a combination of biomimetic recognition chemistry and flexible electrode transduction. The April 2026 Nature Communications paper is the most prominent output to date and almost certainly represents two to three years of preceding development.

Two adjacent Chinese patent filings — CN 202510542070 (Cu(I)-cystine, May 2025 priority), CN 202511387976 (Fe(II)-cystine variant from the same inventor group, late 2025 priority), and a third new filing CN 121186165 (May 2026) — were tracked through our monthly Cu2Cyt patent monitor in advance of the public exchange with Prof. Wu. There is, to date, **no PCT, US or EP family member** for any of these filings. This is the central reason Ambient IoT moved early to file its own Australian provisionals on the array, integration, drift-mitigation, prediction, and AMC embodiments — to establish priority outside China before any of Wu's filings extend internationally.

Prof. Wu's reply to our 10 May 2026 outreach was substantive, candid, and constructive. He acknowledged three points worth noting:

(a) Long-term stability is the real problem. Wu explicitly stated that low temperature is an engineering issue and humidity is solvable with hydrophobic isolation, but multi-month operational stability under mixed VOC and intermittent 1-MCP exposure is the genuine scientific challenge and will require dedicated screening, equipment upgrades for low-temperature characterisation, and an 18–24 month minimum development timeline before evaluation-grade field units are realistic.

(b) He moved to MNDA on his own initiative. A research group that proposes the MNDA structure themselves is one that has had prior commercial collaboration experience, has an institutional path for executing such agreements, and understands the IP architecture required to make a joint program viable. This is a high-quality counterparty signal.

(c) He raised the website-attribution question early. Wu observed that public Moseley/Ambient IoT pages referenced receptor-inspired chemistry without explicit attribution to the Xu et al. paper. Raising it at this stage — rather than waiting until it became material — is a strong signal of good faith. We have since updated the public technology and machine-learning pages to cite Xu et al. with the DOI and to clarify that Ambient IoT's claimed contribution is the integration, drift-mitigation, and ML layer, not the receptor chemistry.

3 · Why this matters commercially

3.1 The selectivity barrier

Every commercial cold-chain ethylene sensor today — electrochemical, photoacoustic, or metal-oxide — gives essentially the same answer in the wrong way. They are sensitive enough; they are not selective enough. A reefer container of avocados is a mixed VOC environment: alpha-pinene, hexanal, ethanol, acetaldehyde, ammonia from residual nitrogen products, and trace 1-methylcyclopropene (1-MCP) where it has been applied to the cargo. None of these is ethylene. All of them register on conventional sensors at concentrations that obscure the ethylene signal that actually predicts ripening.

The biological ethylene receptor evolved precisely to solve this problem. Plants need to distinguish ethylene from a noisy biochemical background within their own tissues at sub-ppb concentrations. The Cu(I)-S coordination chemistry, with its Dewar–Chatt–Duncanson back-bonding to the C=C double bond, is selective for olefins specifically and for ethylene in particular when geometrically constrained as it is in the receptor — and as Xu et al. have now shown it can be in a synthetic analogue. That is the scientific basis for believing biomimetic Cu(I) sensing can clear the selectivity barrier that no engineered chemistry has yet cleared.

3.2 The market that opens

Global post-harvest loss of climacteric fruit (banana, avocado, mango, kiwi, stone fruit, pear, apple) is estimated at 20–35 % of production. A meaningful fraction of that loss is ethylene-driven and occurs in transit between origin and distribution centre. Today, ethylene management in cold-chain transit is dominated by passive scavengers (potassium-permanganate sachets) and slow-release 1-MCP treatments applied at packhouse; there is no real-time sensing component because there is no sensor cheap enough, selective enough, and stable enough to put inside every container.

Industry analyses already size the ethylene-monitoring-for-fresh-produce market at multi-hundred-million USD by 2030, driven primarily by transport and cold storage applications.⁶ A commercially deployable biomimetic Cu(I) chemiresistor — once it survives multi-month operation under the actual cold-chain envelope — converts that market from a sparse, retrospective, sample-based industry into a continuous, predictive, per-pallet industry. That is the transformation Ambient IoT's E-Puck Sentinel V2 (AU 2026904490), E-Platform (AU 2026903866) and E-Sentinel ML (AU 2026903645) filings are designed to capture.

3.3 Why Ambient IoT is the right integration partner

Ambient IoT already has commercial deployment of sensors in fresh-produce cold-chain logistics through its partnership with **AgroFresh**, the global leader in post-harvest ethylene management. The partnership covers temperature and humidity monitoring today across packhouse, reefer transit, and distribution centre, with multi-week, multi-shipment operational data on the precise environmental envelope that any new ethylene chemistry will need to survive. This is the missing piece for any chemistry-side research group: an operating cold-chain channel and a partner with the customer base, the regulatory experience, and the commercial motivation to deploy at scale.

The collaboration thesis is therefore straightforward. Wu's group provides the receptor chemistry. Ambient IoT provides the array architecture, the integration layer (receptor-in-host through E-MOF-Receptor), the drift-mitigation (E-Shield), the ML fusion (E-Sentinel), the device (E-Puck Sentinel V2), the platform (E-Platform), and the commercial route to market (AgroFresh). The Hill Group (Monash + CSIRO, MOFWorx) provides porous-host manufacture at scale. Neither side can deliver the integrated product alone.

4 · IP implications and counter-portfolio position

Ambient IoT's Australian provisional portfolio was constructed with explicit awareness of the Xu et al. publication and the underlying Wu Chinese filings. The architecture is layered: every device, the platform, both vertical applications, and the integration chemistry are claimed at levels above the receptor chemistry itself, so that ownership of the receptor (whether by Wu, by us under licence, or by a third party) does not displace Ambient IoT's commercial position.

| Filing | Title | Position relative to Xu / Wu chemistry |
|------------------------|--------------------------------------|--|
| AU 2026904494 | Metal-Cystine Sensor Array (genus) | Cu/Fe/Co/Ni/Zn/Mn-cystine array architecture + ML fusion + predictive trajectory inference + semiconductor AMC embodiments. Genus filing positioned above any single-metal cystine system including Cu ₂ Cyt. |
| AU 2026904524 | E-MOF-Receptor Composite (genus) | Integration of biomimetic receptors (including Cu(I)-cystine per Xu et al.) into porous hosts — MOFs, COFs, ZIFs, mesoporous silicas. Locks the receptor-in-host integration layer. |
| AU 2026903919 | E-Shield (drift mitigation) | Apparatus and ML methodology for keeping receptor-inspired sensors stable under multi-week cold-chain conditions. Operates downstream of any receptor chemistry. |
| AU 2026903645 | E-Sentinel ML | Inference model that converts heterogeneous sensor streams into climacteric-event risk classifications. Receptor-agnostic. |
| AU 2026904490 | E-Puck Sentinel V2 (device) | Integrated 18-layer puck with dual-mode metal-cystine sensing + sentinel-gated remediation + ML fusion. The commercial vehicle. |
| AU 2026903866 | E-Platform (telemetry & control) | Cloud / edge platform binding sensors, predictions, and remediation into a single operating system. |
| AU 2026903447 / 903448 | Moseley wafer container + adsorption | Semiconductor AMC application route. Receptor chemistry deployable inside FOUPs and reticle pods. |

4.1 What the counter-portfolio does — and does not — claim

It is important to be precise. AU 2026904494 (Metal-Cystine Sensor Array) does not claim Cu(I)-cystine ethylene sensing as a chemistry — that prior art is owned upstream by Xu, Wu, and the older Cu(I) coordination literature. AU 2026904494 claims the array: two or more distinct metal-cystine sensing elements on independently addressable nodes, with an ML fusion layer producing a single calibrated output, plus predictive trajectory inference over the temporal stream, plus the semiconductor AMC embodiment. Any competitor — including a direct Cu₂Cyt licensee in China or elsewhere — must either come up through a chemistry-only product (and lose the array, prediction, and AMC value) or take a licence to AU 2026904494.

Similarly, AU 2026904524 (E-MOF-Receptor) does not claim the receptor chemistry. It claims the integration mode: receptors hosted inside porous frameworks (MOFs, COFs, ZIFs, mesoporous silicas) across six specific integration architectures, with manufacturing, readout,

capture-and-release cycling, and predictive inference. This is the layer that converts a fragile, slow-recovering, lab-only molecular receptor into a hardened, fast, multi-month-stable sensing material — which is precisely the gap Wu identified as the 18–24 month R&D challenge.

4.2 PCT timing

All Australian provisionals have a 12-month convertibility window for PCT extension. The earliest filings (AU 2026903447 / 903448, AU 2026903508) reach PCT decision points in March–April 2027; the most recent filings (AU 2026904494, AU 2026904524) carry through to May 2027. Wu's Chinese family CN 202510542070 reaches its own PCT window earlier — May 2026 — and the absence of any PCT extension to date is the single most important watch-item in the Cu₂Cyt patent monitor. If Wu's institution does not extend internationally during 2026, Ambient IoT's prior-art position outside China hardens substantially.

5 · Risks and adverse scenarios

5.1 The chemistry may not survive cold chain

Wu himself flagged this as the central scientific risk. Cu(I) is an unstable oxidation state under ambient air at ambient temperature; oxidation to Cu(II) destroys the ethylene binding geometry. In the lab, Xu et al. show good reversibility and reproducibility over a short measurement campaign, but multi-month operation under cold, humid, sealed reefer conditions has not been demonstrated. There is a credible scenario in which the chemistry never reaches commercial-grade stability, in which case the receptor-in-host architecture of E-MOF-Receptor — which provides geometric stabilisation, oxygen exclusion, and humidity buffering — becomes the load-bearing IP rather than the receptor itself.

5.2 A competing licensee may emerge

Wu's group may, in parallel with our MNDA discussion, be in contact with other commercial parties — particularly in China where the Cu₂Cyt patent family is already filed and where the domestic agricultural-IoT industry is large. If a competing licensee secures exclusivity on the receptor chemistry outside China before our MNDA converts to a collaboration agreement, Ambient IoT loses preferential access to the chemistry. Mitigation: move quickly on the MNDA, sequence the collaboration proposal to land within 30 days of MNDA execution, and structure the eventual agreement around either field-of-use exclusivity (cold-chain logistics + semiconductor AMC) or geographic exclusivity (ex-China).

5.3 PCT extension into AU/US/EP

If Wu's institution extends CN 202510542070 to PCT and designates Australia, the United States, and Europe before our integration filings convert, the receptor chemistry becomes patent-protected on our home turf. Our counter-portfolio is constructed so that we still own the array, integration, prediction, drift-mitigation, ML, device, platform and AMC layers — but we would need a chemistry licence from Wu's institution to deploy. The MNDA-then-collaboration sequence is also the mitigation here: a friendly licence is preferable to a defensive licence.

5.4 Public attribution and academic relationships

The 11 May 2026 update to the public Moseley and Ambient IoT sites adds explicit citation to Xu et al. (Nature Communications, 2026) and clarifies that Ambient IoT's IP scope is the integration, drift-mitigation and predictive layer rather than the receptor chemistry. This should be sufficient. If Wu raises further concerns after seeing the updated pages, the next step is to offer a co-authored technical brief or joint case study post-MNDA, which converts the attribution question into a collaboration artefact rather than an audit trail.

6 · Recommendations

Six concrete actions follow from this assessment.

1. Send the MNDA draft to Prof. Wu this week, as committed in the 11 May reply. Include the Background IP schedule listing all thirteen Ambient IoT Australian provisionals and explicitly identifying Xu et al. 2026 plus the three Chinese filings as third-party prior art.
2. Pre-draft the post-MNDA collaboration proposal in parallel so it can be sent within 30 days of execution. Frame it as a phased program: Phase 1 — receptor screening under cold-chain conditions (months 1–6); Phase 2 — receptor-in-host integration and humidity hardening (months 6–18); Phase 3 — evaluation-grade units for AgroFresh field trial (months 18–24). Include indicative budget for equipment upgrades at Henan as a commitment of seriousness.
3. Maintain the Cu₂Cyt patent monitor at monthly cadence with explicit watch on PCT extension of CN 202510542070, CN 202511387976, and CN 121186165. Add a watch on new filings from the Xu / Zhang / Wu inventor group covering Fe(II), Co(II), Ni(II), or Mn-cystine variants — the same group is highly likely to extend the chemistry across the transition-metal series, which Ambient IoT's AU 2026904494 array filing already covers.
4. Pursue Hill Group MOFWorx supply discussions in parallel. The Hill side provides the porous-host manufacture that AU 2026904524 (E-MOF-Receptor) requires, and a license-in + supply structure with Hill is the natural complement to a chemistry licence-in from Wu. Two complementary upstream relationships, neither displacing Ambient IoT's integration IP.
5. Pre-PCT adversarial review of all thirteen Australian provisionals before any of them converts. The receptor-in-host integration genus filing (AU 2026904524) is the most strategically important and the most recently filed; it deserves the most rigorous claim-by-claim review before May 2027.
6. Brief AgroFresh on the strategic significance of the Wu chemistry under existing NDA. The eventual cold-chain product is jointly enabled by AgroFresh's customer access, our integration IP, Wu's chemistry, and Hill's hosts; AgroFresh should be made aware that the chemistry channel exists and is being secured.

STRATEGIC POSTURE

Treat Wu's chemistry as a foundation we want to build on, not a threat we need to defend against. The Ambient IoT portfolio is already structured to own the value above the chemistry — the array, the host, the prediction, the drift-mitigation, the device, the platform, the deployment channel. Securing collaborative access to the chemistry, on friendly terms, converts a multi-year scientific risk into a 12 – 24 month product programme.

Sources

- [1] Xu, L., Zhang, B., et al. A plant-receptor-inspired cuprous complex for wearable trace-level ethylene gas sensing. *Nature Communications*, 2026. DOI 10.1038/s41467-026-71748-7. <https://www.nature.com/articles/s41467-026-71748-7>
- [2] Rodríguez, F. I., Esch, J. J., Hall, A. E., Binder, B. M., Schaller, G. E., Bleecker, A. B. A copper cofactor for the ethylene receptor ETR1 from *Arabidopsis*. *Science* 283 (5404), 996–998, 12 February 1999. <https://www.science.org/doi/10.1126/science.283.5404.996>
- [3] Schott-Verdugo, S., Müller, L., Classen, E., Gohlke, H., Groth, G. Structural Model of the ETR1 Ethylene Receptor Transmembrane Sensor Domain. *Scientific Reports* 9, 8869 (2019). <https://www.nature.com/articles/s41598-019-45189-w>
- [4] Chen, W. Y., Yermembetova, A., Washer, B. M., Jiang, X., Shuvo, S. N., Peroulis, D., Wei, A., Stanciu, L. A. Selective Detection of Ethylene by MoS₂-Carbon Nanotube Networks Coated with Cu(I)-Pincer Complexes. *ACS Sensors* 5, 1699–1706 (2020). <https://pubs.acs.org/doi/10.1021/acssensors.0c00344>
- [5] Henan Agricultural University, Photonics and Laser Spectroscopy Laboratory (Prof. Junfeng Wu). <https://hjlaser.henau.edu.cn/>
- [6] Ethylene Monitoring for Fresh Produce Loads Market — Research Report (Growth Market Reports, 2025). <https://growthmarketreports.com/report/ethylene-monitoring-for-fresh-produce-loads-market>
- [7] Cu2Cyt patent monitoring cron — internal Ambient IoT monthly surveillance baseline, last refreshed 9 May 2026. <https://www.perplexity.ai/>
- [8] Internal correspondence Tony Raftis ↔ Junfeng Wu, 10–11 May 2026.

Document classification: Internal — Ambient IoT Pty Ltd only. Not for circulation to Prof. Wu, AgroFresh, the Hill Group, or any other external party. Status: working internal brief — sections 4 (IP implications) and 5 (risks) are subject to further analysis once the MNDA is executed and we have visibility into Wu's research roadmap.